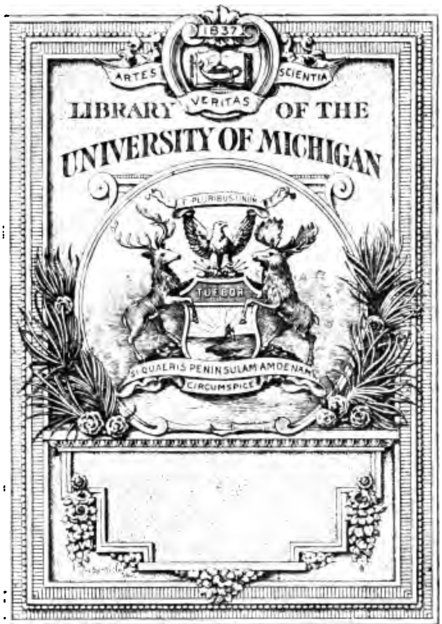

PROCEEDINGS

OF THE

IOWA ACADEMY OF SCIENCES

FOR 1896.

VOLUME IV.

EDITED BY THE SECRETARY.

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1897.

LETTER OF TRANSMITTAL.

AGRICULTURAL COLLEGE,
AMES, Iowa, January 28, 1897.

To His Excellency, FRANCIS M. DRAKE, *Governor of Iowa:*

SIR—In accordance with the provisions of chapter 86, laws of the Twenty-fifth General Assembly, I have the honor to transmit herewith the proceedings of the eleventh annual session of the Iowa Academy of Sciences.

With great respect, your obedient servant,

HERBERT OSBORN,
Secretary Iowa Academy of Sciences.

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1896.

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1897.

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Second Vice-President.—B. FINK.
Secretary-Treasurer.—HERBERT OSBORN.
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RODWELL, W. W. .... Marshalltown
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BEACH, S. A.......................................Geneva, New York
BESSEY, C. E.......................State University, Lincoln, Nebraska
BRUNER, H. L.......................................Irvington, Indiana
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WINSLOW, ARTHUR ....Kansas City, Missouri

PROCEEDINGS

OF THE

ELEVENTH ANNUAL SESSION

OF THE

Iowa Academy of Sciences.

The eleventh annual session of the Iowa Academy of Sciences was held in committee room No. 1 of the capitol building in Des Moines, December 29 and 30, 1896. In business sessions the following matters of general interest were acted upon.

REPORT OF THE SECRETARY-TREASURER.

MEMBERS OF THE ACADEMY—The past year has been one of substantial progress for the Academy. We have added five fellows and seven associate members. Our proceedings were duly printed and form a volume of 230 pages.

It is my sad duty to chronicle the death of one of our most honored members, Dr. Chas. Wachsmuth, of Burlington, who died very soon after our last meeting. I would suggest that a committee be appointed to draft suitable resolutions to be published in our forthcoming volume of proceedings and to include, if possible, a sketch of his life.

FINANCIAL STATEMENT.

Accounts and vouchers submitted herewith show receipts of $151.69 and expenditures of $79.72, leaving a balance charged to the treasurer of $71.97.

SUMMARY OF RECEIPTS AND EXPENDITURES.

RECEIPTS.

Balance from last year	$ 55.99
Membership fees	37 00
Annual dues from members	55.00
Proceedings sold	4.70
Total	$151.69

EXPENDITURES.

Stamps and stamped envelopes	$ 4.84
Printing programs, notices, receipts, etc.	11.00
Reprints of author's extras	32.00
Express and postage on proceedings	21.91
Miscellaneous items of expense	9 97
Total	$ 79.72

The committee on treasurer's accounts reported as follows:

To the Iowa Academy of Sciences: Your committee appointed to examine the accounts of the treasurer find the same to be correct.

(Signed) G. E. FINCH,
A. A. VEBLEN,
A. G. LEONARD,
Committee.

Resolutions urgently opposing the pending bill in congress for the restriction of experiments on living animals were passed, also one in support of the movement for a director of scientific bureaus in the department of agriculture.

A subscription was voted for the Pasteur monument fund.

In addition to the appended papers, read in full or by title and which were by vote of the council referred to the secretary for publication, the following subjects were presented:

Mr. Charles Carter, of Fairfield, remarked upon the Iowa Odonata, calling attention to what had been done in the way of study of our native species and requesting the members to assist him by sending specimens of such species as they could with a view to the preparation of a catalogue of the species of the state.

Prof. A. H. Conrad, of Fairfield, read some preliminary notes on the Ophidia of Iowa, indicating the extent to which the species of the state are known, the probability of the rapid extermination of many of the species and the desirability of a prompt study of our native fauna. He requests material and correspondence.

Professor Conrad exhibited an archæological specimen recently unearthed near Fairfield: a small box hollowed from

Yours very truly
Charles Wachsmuth

two pieces of wood evidently hermetically sealed and which contained sheets of birch bark bearing aboriginal hieroglyphs.

The committee appointed to prepare a memorial in honor of Dr. Charles Wachsmuth and consisting of Prof. Samuel Calvin and Dr. Charles R. Keyes, presented the following sketch, prepared by the long time friend and former co-laborer of Dr. Wachsmuth, Dr. Charles R. Keyes. The plate for the portrait was kindly loaned by Mr. Charles Aldrich, of the historical department.

MEMORIAL OF CHARLES WACHSMUTH.

Since our last annual gathering the Academy has lost one of its most illustrious and honored members, the state one of its most distinguished citizens and American science one of its most indefatigable workers. By the death of Charles Wachsmuth an epoch in the history of Iowa science closes. To those of you who were intimately acquainted with our departed friend and associate no words that we can utter will seem extravagant. Yet it appears befitting at this time, especially for the consideration of those of you who were not so fortunate as to come in frequent contact with him, to give some estimate of his personality and worth.

Charles Wachsmuth was born September 13, 1829, in the city of Hannover, Germany. He was the only son of a lawyer of considerable reputation who was a member, in 1848, of the German parliament of Frankfurt. From early childhood he was always in feeble health. It was the wish of his father that he should study law, and he was accordingly sent at an early age to the high school of his native place to receive a classical education; but to his father's great grief and his own, he was obliged, at the age of sixteen, to give up all studies on account of failing health, and on the advice of the attending physician to enter a mercantile career.

In 1852 the young Hannoverian came to America, having been sent to New York as an agent of a Hamburg shipping house, in which capacity he served for a period of over two years. Severe illness compelled him to leave the sea coast, and upon the advice of friends he settled in Burlington. In 1855 Mr. Wachsmuth was married, and in the same year embarked on his own account. The dry, western country did not bring about the expected improvement in health, and his physician advised that as much time as possible should be spent in the open air, suggesting that the collecting of fossils, which abounded in the rocks of the neighborhood, would soon provide an incentive for sufficient exercise. It did not take long for him to develop into an enthusiastic collector, so that days at a time were spent in quarries and ravines around the city, his wife often looking after the store. The new mode of life at once produced a wonderful improvement of health. In the course of a few years a fine collection of crinoids had been brought together. It reached such dimensions that it attracted

the attention of eastern scientists. Prof. Louis Agassiz came to see it on his lecturing trip to the west, and Meek and Worthen asked the loan of specimens for description in the geological reports of Illinois, which were then being prepared.

In 1865 Mr. Wachsmuth closed out his business and, accompanied by his wife, made a trip to Europe. On his way he visited Cambridge, upon invitation of Professor Agassiz, and saw the large collections in the Museum of Comparative Zoology. Until then he had seen very few crinoids aside from those found at Burlington. His delight knew no bounds as he studied in Cambridge the fossil crinoids from other localities, and a number of specimens of living types. In Europe all sorts of invertebrate fossils were collected and visits made to the principal museums. When England was reached it was a great surprise to find that the reputation of the Burlington collection had already preceded him.

On returning to Burlington, after an absence of almost a year, Mr. Wachsmuth resolved to devote the rest of his life to scientific pursuits, and to direct his whole attention to crinoids. Living far from scientific centers, and not having access to literature, he had to depend for study largely upon his own specimens. This, however, proved afterwards an advantage, rather than a drawback, for independent thought and original research.

It was in 1873 that Professor Agassiz, on his return from the Pacific coast, paid a second visit to Burlington. He was greatly surprised at the enormous growth of the collection since he had last seen it, and, struck by the beauty and perfection of the specimens, he intimated that he was anxious to procure the collection for Cambridge, at the same time expressing a desire to have Mr. Wachsmuth go with it and take charge of all the crinoids in the museum. The negotiations were soon completed, and a few months later Mr. Wachsmuth was installed in the Museum of Comparative Zoology as an assistant. It was Professor Agassiz who induced the new assistant to publish the results of his observations under his own name, on the ground that he was doing a great injustice to himself by placing them in the hands of others. The position, which was held until the death of Professor Agassiz, gave ample opportunity for Mr. Wachsmuth to become fully acquainted with the literature on the crinoids, and it was here that the foundation of the later great work was laid.

After the death of Agassiz a second trip to Europe and a visit to the Orient, was made. On returning in 1874 Mr. Wachsmuth had not a single specimen in his possession. However, it took only a few years to make up another collection that was larger and much superior to the first. A year or two later he made the acquaintance of Mr. Frank Springer, then a young lawyer of Burlington, and an enthusiastic student of the natural sciences; a warm friendship soon sprung up between them. They studied together, and from 1878 the results of their researches were published under joint authorship. In the following years the collections increased rapidly by extensive purchases. From a trip to Europe Mr. Springer brought home a fine selection of Dudley crinoids, embracing nearly all of the species of that locality, and a large assortment of the Carboniferous species of England and Ireland. Among his acquisitions were also rare forms from Belgium, a majority of the Eifel species, fine specimens from Russia and Bohemia, and a large amount of material from the Mesozoic and later formations. The collection was enlarged further by extensive

exchanges with collectors in this country and Europe, and by having collectors in the field. Liberal purchases for the library were made, and when work was commenced on the monograph, nearly the whole crinoidal literature, from the time of J. S. Miller to date, was at hand. By examining the titles of their publications it will be noticed that Wachsmuth and Springer took very little pride in describing new species, their attention being directed mainly to the morphology, with a view to classification, and to the revision of the work of the earlier writers. As the work of the monograph was nearing completion, Prof. Alexander Agassiz, the present director of the Museum of Comparative Zoology, offered to publish it, in the best style possible, as one of the memoirs of the museum, and in this series it now appears, a model of typographic art.

Mr. Wachsmuth was at one time vice-president of this society. He was also a fellow of the American Association for the Advancement of Science, of the Geological Society of America, and of the Davenport Academy of Sciences. He was a corresponding member of the Philadelphia Academy of Natural Sciences, and a member of the Imperial Society of Natural Sciences, of Moscow, Russia. For many years he carried on an extensive and intimate correspondence with leading scientists of this country and Europe. That which passed between Dr. P. Herbert Carpenter, the most eminent European authority on Echinoderms, and Mr. Wachsmuth during the past ten years would alone fill a large volume.

For many years Mr. Wachsmuth was in delicate health and was obliged to spend the winter seasons in the South. The early spring was usually passed in the mountains of Alabama, Tennessee and Kentucky, where immense collections of both crinoids and blastoids were brought together. On all of these trips he was accompanied by his faithful wife, who is, herself an excellent and indefatigable collector.

The sudden demise of our associate took place on February 7, 1896.

Although rarely able to be present at the meetings of our Academy no member took greater interest in its deliberations nor had greater solicitude for its welfare and progress.

From early childhood Mr. Wachsmuth possessed a frail constitution which continually threatened to give away, yet he withstood the inroads of an organic disease long enough to nearly complete the allotted span of human life, of three score years and ten. During the last three years his health gradually failed, until for several months previous to the end, herculean efforts were necessary to enable him to work even for a short time each day. His last illness covered only a few days, and even the iron will, which had so often before overcome a long-standing ailment, finally had to give up to the physically weak heart. To within a day of his demise, with a zeal that is begotten only for love of the sublime, he continued to apply himself to the finishing stages of the crowning glory of his life—the Monograph of the Fossil Crinoids. The first half only was written and the final proofs of this part were barely read when the angel of death beckoned him. The triumphant joy of beholding the completed structure of a noble life's work was not his lot. Deprivation of what he held dearest took the place of conquering satisfaction, in the very hour of victory.

Few outside of the little circle of workers directly interested in the rather limited field of investigation can appreciate the great importance and originality of Mr. Wachsmuth's work. Compared with the extent of

the great field of science itself the results may seem small; measured by the standard of individual achievement the outcome is stupendous. In the special department of knowledge which he represented no one person has done more to raise it to the high place that it now occupies.

Wachsmuth belonged to that illustrious school of naturalists which Louis Agassiz founded in this country. His main efforts were entirely along the lines of inquiry pointed out by the Swiss savant. It was the establishment, upon a morphological basis, of a rational classification of a group of organisms. The group chosen was the crinoids, or sea lilies, a class of animals which is now all but extinct, but which in ages past was one of the most abundant forms of life. Most of the material was fossil and the difficulties surrounding the investigation were such as to students of living animals would be insurmountable. Although the work was far from finished at the time of his demise the main and most important features of the scheme were fully established and the Wachsmuth classification of crinoids has been adopted the world over.

In the Monograph of the Fossil Crinoids, which is a huge quarto of 800 pages in two parts and an atlas of eighty plates, is contained the mature reflections of thirty years' continuous thought and reflection. Twenty years ago, when at Cambridge with Agassiz, the foundations of his life's work were laid. In a little paper "On the Internal and External Structures of Paleozoic Crinoids," published in 1877, was stated the essential propositions on which rested all subsequent work. The ancient crinoids were divided into three primary groups, the separation being based chiefly upon the structure of the tegmen.

The effects of Wachsmuth's work has been completely to revolutionize the ideas which prevailed concerning the crinoids and to place the whole systematic arrangement of the groups upon an enduring basis. The stages in the development of those changes are easily traced in the various publications which were issued from time to time and culminated in the monumental monograph.

THE STATE QUARRY LIMESTONE.

BY SAMUEL CALVIN.

At the state quarries, or North Bend quarries, in sections 5 and 8 of Penn township, Johnson county, Iowa, there is a body of limestone of Devonian age, possessing marked characteristics which set it off sharply from the rest of the Devonian in the upper Mississippi valley. The formation has a thickness of about forty feet. At present there is some uncertainty as to its exact taxonomic relations.

On fresh fracture the state quarry rock is light gray in color. In texture it varies somewhat in different beds, but

near the middle of the formation it is composed of coarse, imperfectly comminuted fragments of brachiopod shells cemented together, the spaces being filled with interstitial calcite. Among the recognizable species of shells *Atrypa reticularis* is the most common, but some beds contain very large numbers of *Terebratula* (*Cranæna*) *iowensis*. At some horizons shells of an Orthothetes are common. *Orthis impressa* is not rare, and *Rynchonella pugnus* (*Pugnax pugnus*) occurs occasionally. The shells, or fragments of shells, making up the limestone are not embedded in a matrix. They are simply piled on each other and cemented together in a manner illustrated by the formation of the modern coquina along the east coast of Florida. The rocks near the middle of the state quarry beds are a brachiopod coquina having the interstices completely filled with crystalline calcite.

Near the middle of the formation the rock consists of thick ledges which, some years ago, were worked extensively. From these beds came the large limestone blocks used in the foundation of the new state capitol. Although the ledges show no definite lamination, and split as readily in one direction as another, the weathered surfaces on opposite sides of the numerous joints often show obscure signs of oblique bedding. The material was evidently swept into place by moderately strong currents.

The ledges worked in connection with the building of the new capitol are the heaviest afforded by the formation. The lowest one is four feet in thickness. It is made up of rather finely triturated brachiopod shells, the most common species being *Atrypa reticularis*. This bed, it seems, did not furnish satisfactory material for it was quarried only to a limited extent. The ledge furnishing the greater number of available blocks lies directly above the first. It is five feet in thickness, and is intersected by numerous joints. Among the great multitude of unrecognizable fragments of which it is chiefly composed it contains large numbers of entire detached valves of Atrypa and Orthothetes. The next ledge in ascending order to furnish usable stone is separated from the last by a talus-covered space of two or three feet. It also is five feet thick, and in it Atrypa and Terebratula are the prevailing brachio pods. In a fourth ledge, four feet in thickness, the rcck is fine grained, the materials are very perfectly comminuted, species cannot be recognized, but it is evident that the bed is composed of debris from brachiopod shells mingled with triturated fragments of crinoids. Above the fourth ledge the layers vary

from six inches to two feet in thickness, and toward the upper part of the exposure the rock is made up almost wholly of the remains of crinoids.

Below the first ledge noted above the beds vary from a few inches to a foot or more in thickness, the thinner beds prevailing near the base of the formation. Brachiopod shells constitute the major part of the material of which they are composed.

Among the waste material of the main quarry there are many large blocks, eighteen inches thick, through which masses of chert are irregularly distributed. The position of the bed from which the chert-bearing blocks were obtained was not determined, though it is probable that it lies in the talus-covered space between ledges two and three of the main workable portion of the quarry. Whatever its position, it is a bed of remarkable interest, for it is in places crowded with fish teeth that lie embedded in the chert or among triturated brachiopod shells in the calcareous portions of the layer. It looks as if an entire fish fauna had suffered death at once. Such general fatality may have been produced by any one of several probable causes; and, furthermore, the cause was doubtless in some way related to the crustal movements recorded in the region, and to be noted further on. Changes in oceanic currents attended by rapid elevation or depression of temperature, earthquake shocks even, or concentration of sea water in an isolated basin, would be competent to produce the observed result. Whatever the cause, it was effective, and every square yard of sea bottom received its quota of dead fishes.

Several genera and species are indicated amid the profusion of fish remains interred in this old cemetery. One of the most common forms is the well known Devonian type, Ptyctodus. Teeth of this genus are sometimes literally crowded together to form a sort of fish tooth conglomerate. These teeth, or tritors, vary in size and shape and in the degree of wear to which they were subjected before the death of their owners; but in the opinion of experts to whom they have been submitted, they probably all belong to the single species, *Ptyctodus calceolus*. Along with Ptyctodus are remains of one or more species of Devonian Placoderms, as indicated by great numbers of imperfect dermal plates. The Dipnoan genus, Dipterus, is represented by a number of the interesting wing shaped teeth characteristic of this very old but persistent type; and there are

teeth evidently related to Dipterus, but so different as probably to make generic separation necessary.

But more interesting than all the rest, and far outnumbering the teeth that could at first sight be referred to Dipterus or to related genera, is a vast assemblage of teeth of varying shapes and dimensions, that bear a striking external resemblance to the crushing teeth of certain genera of sharks. In the opinion of Dr. C. R. Eastman, however, it is doubtful if there are any Selachian teeth in the entire lot. He finds that, microscopically, they all, so far as sections have been made, are identical in structure with the teeth of Lung fishes, or Dipnoans. They seem, indeed, to be primitive Dipnoans exhibiting a stage of evolution not far removed from the point whence the Dipnoan and Elasmobranch types diverged; and their careful study will doubtless throw much light on the nature of the relationships existing between these two groups of fishes. Dipterine fishes have long been known from the Devonian of eastern Europe, but it is only recently that this type has been found in the Devonian of America. Until the discovery of the State quarry fish bed, our Devonian Dipterines all belonged to a single genus and came from the upper Devonian formations of Pennsylvania. Now we find the type in the Mississippi valley, and here it is represented by several genera, and is connected by intergradations with exceedingly primitive Dipnoan forms. The material has been placed in the hands of Dr. Eastman, whose full report on the subject will be awaited with much interest.

Distribution.—At present the state quarry limestone is known only in Johnson county, Iowa, though it doubtless occurs at other points in Iowa and adjacent states. The main body occurs in sections 5 and 8 of Penn township (T. 80 N., R. 6 W.). It is found in the bluffs on the west side of the Iowa river from the north line of section 5 to a little more than one-fourth of a mile below the north line of section 8, the principal development occurring near the south side of the first named section. The width of the area occupied by the formation in this region is less than half a mile. In fact in following up the small tributary valleys the state quarry stone is in most cases found to disappear in less than one-fourth of a mile.

A second body of state quarry limestone is found near the southwest corner of section 20, of Graham township, at which point the formation is almost exclusively crinoidal as to composition; a third body of this limestone, but of no great thickness,

is seen near the top of the hill southeast of the bridge over Turkey creek in section 23, Newport township; and another body of the same stone occurs in rather puzzling relations to the Megistocrinus beds in section 23, Big Grove township, southwest of Solon. At the last named locality Rynchonella, or Pugnax, is the prevailing fossil. The very fossiliferous limestone seen near the base of the quarry south of Shueyville is of a very different character and belongs to a different horizon.*

Taxonomic Relations.—As already intimated, the taxonomic relations of the state quarry stone are not very clear. At first it seemed that it might possibly represent local deposits made contemporaneously with the Cedar valley beds, but later investigations indicate that it is younger than the Cedar valley and was laid down on a deeply eroded surface. In support of this view it may be noted that at the mouth of the ravine below the south quarries in section 5 of Penn township, the state quarry stone rests on the Megistocrinus beds of the Cedar valley stage. In following up the ravine the quarry stone rises higher and higher in the bluffs and soon disappears, while the members of the normal Cedar valley section appear successively in the bottom of the creek. The contact of the two formations cannot, however, be definitely traced. On Rapid creek, in section 20 of Graham township, the relations are nearly the same. The state quarry stone occurs only a short distance above the Megistocrinus beds. At Solon the equivalent of the quarry stone occurs on the west side of a small ravine, while on the east side of the ravine, only four or five rods distant, the typical Megistocrinus beds, wholly different in character and with an entirely different fauna, occur at the same level. The quarry beds at the last named locality are composed largely of shells of Pugnax (Rynchonella). They extend westward along the north side of the valley of a small creek for about one-eighth of a mile and then suddenly disappear, their place in the low bluff being taken by the normal Megistocrinus beds of the Cedar valley section.

In the bluffs above the bridge over Turkey creek, at the point already noted, in section 23 of Newport township, these beds occur above the white limestone at the top of the Cedar valley formation. No Devonian beds of any kind have so far been

*McGee: Tenth Census Rept. Vol. X, Quarries and Building Stone, p. 262.

found above the state quarry stone. The anomalous relations of this formation, the limited areas to which it is confined, the abrupt manner in which it appears and disappears, sometimes at the level of one member of the Cedar valley section and sometimes at the level of another, all lead to the conclusion that it was deposited uncomformably on the Cedar valley limestone after the lapse of a considerable erosion interval. The same view is even more strongly suggested by the fact that in certain respects the fauna of the state quarry beds is unique. The deposit near Solon furnishes *Pugnax pugnus* Martin, *Melocrinus calvini* Wachsmuth, and a very peculiar Stromatoporoid, none of which are found in the other Devonian formations. Of other species that have a greater vertical range, as for example *Atrypa reticularis*, there is sufficient variation to distinguish them from individuals of the same species found at other horizons. The Orthothetes, so common in the beds in section 5 of Penn township, is associated with Pugnax, and like it is limited to the state quarry stage. The great mass of cemented crinoidal debris composing the beds in Graham township and the upper ten or fifteen feet of the formation at the state quarries has no parallel in any other stage of the Iowa Devonian. The presence of Dipterus, which elsewhere occurs only in the Upper Devonian, is likewise indicative of an interval between this stage and the Cedar valley beds below. In this connection it may be noted that the affinities of *Pugnax pugnus* is with the Carboniferous rather than the Devonian. These facts, coupled with the evidence of unconformity, would seem to place the formation near the closing stage of the Upper Devonian system, while the faunas of the Cedar valley stage correlate it with the Middle Devonian. The known phenomena concerning the state quarry limestone and its interesting fauna evidently require for their interpretation a number of crustal movements and a long period of erosion in the Iowa Devonian heretofore unsuspected.

STAGES OF THE DES MOINES, OR CHIEF COAL-BEARING SERIES OF KANSAS AND SOUTHWEST MISSOURI AND THEIR EQUIVALENTS IN IOWA.

BY CHARLES R. KEYES.

The principal coal-bearing formation of Iowa and other parts of the western interior basin is the lower coal measures, or Des Moines series as it is now termed. Although the formation has been long recognized in practically its present geologic limits it has been only very recently that any attempt has been made to even suggest subdivisions of the series. It is to these minor distinctive parts that have been made out clearly in southwest Missouri and the adjoining portions of Kansas that attention is directed.

Over the whole of its areal extent in the western interior coal field the Des Moines series, or productive coal measures, is clearly limited above by the Bethany limestone and below by the Mississippian limestones, or earlier formations. Until very recently no attempt has been made to subdivide the principal coal-bearing series of the region. Minor divisions have been vaguely recognized, however, in different parts of the area occupied by these rocks. In the southwestern extension of the belt the most definite information in regard to the detailed relations of the various strata has been obtained. In that part of western Missouri south of the Missouri river three stages have been traced out. They are known to extend northeastward into other parts of the state. Since these have been determined very similar lines have been recognized in Kansas, where special names have been applied.* The three stages that are capable of more or less clear demarkation in Missouri and Kansas are the Cherokee shales, at the bottom, the Henrietta limestones, and the Pleasanton shales at the top.

Cherokee Shales.—The term Cherokee as a designation for the lower part of the coal measures was first applied by Haworth

*Univ. Geol. Sur., Kansas, vol. I, p. 150, 1896.

and Kirk.* While it was not formally nor properly defined as a formation name subsequent description† leaves practically no doubt as to its extension. The name had been previously used by Jenney for the lead-bearing formations of the Mississippian series of southwest Missouri but only incidentally, and before it was proposed formally to use the title‡ thus, the term had been appropriated in another sense. Moreover, Cherokee, as applied to the lead-bearing rocks, covers an indefinite sequence of beds for which specific titles that are not well defined have been already adopted, so that even if the term in this sense had been formally suggested it could scarcely be considered as having priority. In this sense also the term has nowhere been accepted as a geological name, while it has been practically refused recognition by all who have had occasion to refer to it, either directly or indirectly.

The Cherokee contains a number of minor formations to which special names are applicable locally. These require no definition. They refer more directly to the coal seams, and thick sandstones.

Henrietta Limestone.—The name Henrietta was used by Marbut§ for a subdivision of the coal measures which gives rise, in southwestern Missouri, to a prominent physiographic feature called the Henrietta escarpment. It consists of several limestone beds of great persistency separated by shales, but presenting a sharp contrast to the underlying and overlying formations which consist of shales and sandstones.

In southeastern Kansas it embraces of Swallows sections‖ essentially numbers 203 to 217, or from the top of the Pawnee limestone down to the cement rock under the Fort Scott limestone. In the more recent references¶ to these beds the same limestones are recognized but the lower bed is termed the Oswego limestone.

The Henrietta formation, in southwestern Missouri and southeastern Kansas at least, is a three-fold division, having an upper and a lower limestone separated by shale thirty to fifty feet thick and carrying thin beds of limestone.

To the lower or calcareous number the term Fort Scott limestone is properly applied. This is the name used by Swallow,

*Kansas Univ. Quart., vol. II, p. 105, 1894.
†Univ. Geol. Sur., Kansas, vol. I, p. 150, 1896.
‡Trans. American Inst. Min. Eng., vol. XXII, p. 171, 1894.
§Missouri Geol. Sur., vol. X, p. 44, 1896.
‖Kansas Geol. Sur., Prel. Rep., pp. 24-25, 1866.
¶University Geol. Sur., Kansas, vol. I, p. 151, 1896.

whose meaning can be easily defined. More recently another title has been given to practically the same formation, but as the two are essentially coterminous it seems that the earlier of the two can be retained with advantage. The latter term includes only a few layers additional, which are also well exposed at the typical locality. The latter term is Oswego, which, though used previously without definition, was described only very recently.*

The medial shale member may be designated as the Marmaton formation from the stream of the same name in Vernon county, Missouri, and Bourbon county, Kansas, where the shale may be considered as typically developed.

The Pawnee limestone forms the upper member of the Henrietta. The term was first used by Swallow† for a heavily bedded limestone occurring in southeastern Kansas.

Pleasanton Shales.—The name Pleasanton was first applied by Haworth.‡ There is, however, some difficulty in determining just what title is the proper one to use in this connection. Swallow§ seems to have had essentially the same idea in applying to the principal coal-bearing shales immediately overlying the Pawnee limestones in southeastern Kansas, the term "Marais des Cygnes coal series." He, however, appears to have gotten the upper part considerbly mixed, especially the limestones, if later work is to be relied upon. Only the lower half of this coal series can be regarded as forming the equivalent of the Pleasanton, or numbers 194 to 202 of Swallow's section. These beds are typically exposed in Bourbon county, and along the Marais des Cygnes river in Linn county, Kansas, the locality being practically the same as that in which the town of Pleasanton is situated, so that the original localities for both are essentially the same. The "series," however, evidently embraces so much more than it should to form a compact, easily defined formation, and the upper part, moreover, is so far from being correct that it would seem best not to attempt to restrict and redefine the limits of the formation in order to retain the name.

For the strata lying between the Pawnee and Bethany limestones Haworth and Kirk‖ first suggested the name Laneville

*Univ. Geol. Sur., Kansas, vol. I, p. 151, 1896.
†Kansas Geol. Sur., Prelim. Rep., p. 24, 1866.
‡Kansas Univ. Quart., vol. III, p. 274, 1895.
§Kansas Geol. Sur., Prelim. Rep., pp. 22-24, 1866.
‖Kansas Univ. Quart., vol. II, p. 108, 1894.

shales. Had this term been defined in any way it would probably have to be adopted as the designation of the formation. Subsequently Haworth* without the slightest reference to this title, and without a very much better definition for the new name changed it to Pleasanton shales. As in a later publication† the latter term has been more clearly limited and applied, it should probably be regarded as the proper designation of the formation.

In Iowa there are recognizable in the Des Moines series (1) an upper shale bed of considerable thickness, which lies beneath the Bethany or Winterset limestone, (2) a lower shale bed, 300 to 400 feet thick which rests on the Mississippian and older strata, and (3), between the two, a set of beds that includes limestone layers which, though comparatively thin, rarely more than four to six feet, are of relatively great lateral persistency and carry at least one seam of workable coal. In southern Iowa the last mentioned beds appear to be best developed in Appanoose county and the adjoining districts. The Mystic coal, the seam having the greatest areal extent of any in the state, is included in this median member. The limestone beds are closely associated with the coal. The strata have a total thickness of perhaps seventy-five feet. They indicate an epoch, during which temporarily, marine conditions prevailed to a greater extent than during any other time between the secession of Mississippian deposition in the region and the introduction of the Missourian.

The exact relation between these particular subdivision lines of the strata of Iowa and of southwest Missouri have, of course, not been directly traced in detail, but the close resemblance of the vertical sections is so striking and the probabilities of their being equivalent are so great that it seems worth the while, at this time, to call attention to the facts, while the top and bottom of the Des Moines series, as a whole, has been clearly made out over the entire region.

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*Kansas Univ. Quart., vol. III, p. 274, 1895

†Univ. Geol. Sur., Kansas, vol. I, p. 153, 1896.

VERTICAL RANGE OF FOSSILS AT LOUISIANA.

BY CHARLES R. KEYES AND R. R ROWLEY.

Owing to peculiar phases in the erosion of the Mississippi river in northeast Missouri the basal portion of the Lower Carboniferous rocks is exposed to better advantage than perhaps anywhere else in the whole interior basin. In Pike county, Missouri, and in the contiguous parts of Illinois, not only does the lower part of the Carboniferous crop out along the streams, but vertical sections from the Hudson shales up to the Upper Burlington are obtainable in single exposures. In this locality the bluffs are high and the outcrops of the rocks under consideration are practically continuous along the great river for a distance of more than seventy-five miles.

The section at Louisiana, which may be regarded as typical, is given below, essentially as when first published several yeas ago,* except that for the present purpose, smaller zones are recognized.

SECTION OF ROCKS EXPOSED AT LOUISIANA, MISSOURI.

TERRANES.	Number	FORMATIONS.	Feet.
Pleistocene.	21	Soil, and red residuary clay, with abundant chert fragments	4
Upper Burlington limestone.	20	Limestone, brown, rather thinly bedded and cherty..	28
	19	Limestone, compact, thin-bedded, encrinital, with much gray chert in bands and nodules..............	18
	18	Limestone, yellowish-brown, rather soft, encrinital...	4
Lower Burlington limestone.	17	Limestone, bluish, fine-grained, siliceous..............	4
	16	Limestone, massive, white, encrinital, coarse-grained (upper white ledge)..............	12
	15	Limestone, brown, encrinital, with irregular chert bands and nodules, and occasional thin clay partings	20
	14	Limestone, white, very heavily bedded, encrinital, some white chert (lower white ledge)	9
	13	Limestone, brown, encrinital, heavily bedded..........	6
Chouteau(?) limestone.	12	Limestone, yellow, massive, or heavily bedded, rather soft, fine-grained..............	9
Hannibal shales.	11	Shale, brown, very sandy, passing into soft sandstone locally..............	12
	10	Shale, green, sandy above..............	60

*Am. Jour. Sci., (3) vol. XLIV, p. 448, 1892.

SECTION OF ROCKS EXPOSED AT LOUISIANA—CONTINUED.

TERRANES.	Number.	FORMATIONS.	Feet.
Louisiana limestone.	9	Limestone, buff to gray, compact, very fine-grained, in layers four to six inches thick, similar to lithographic stone in texture	34
	8	Limestone, similar to above	8
	7	Limestone, similar to above, layers thicker and separated by buff sandy partings	6
	6	Shale, buff, sandy, two to six inches	½
Western Hamilton.	5	Shale, green or dark blue	2
	4	Shale, black, fissile	4
Niagara?	3	Limestone, magnesian, buff, massive	2
	2	Oolite, white, massive	8
Hudson.	1	Shale, blue, with thin bands of limestone, near Louisiana	40

The basal member of the section is the Hudson shale. When fully exposed in the neighborhood it attains a thickness of about seventy feet. It rests on a heavy magnesian limestone carrying characteristic Trenton fossils.

The next two higher members, Nos. 2 and 3, are provisionally referred to the Niagara. The oolite appears to be somewhat of a local phase, but is present not only in the vicinity of the town but all the way to Paynesville, a distance of eighteen miles. The formation appears to be represented elsewhere in the vicinity by fossiliferous limestones which are not oolitic. The organic remains contained are rather abundant. The buff massive layer is very thin at Louisiana, being only two feet in thickness in the river bluff in front of the town. Two miles southward, at the mouth of Buffalo creek, it increases to nine feet, and still further southward, on both sides of the Mississippi river, and southwestward toward Bowling Green, it attains a measurement of twenty-five to thirty feet in a distance of fifteen to twenty miles. It is almost destitute of fossils.

The next two, Nos. 4 and 5, belong to the Devonian. The lower black shale contains a characteristic fish fauna.

Numbers 6 to 9 form the Louisiana division of the Kinderhook. It is the lithographic limestone of the older state reports. For a long time the lithographic limestone has been regarded as the basal member of the Lower Carboniferous in the Mississippi valley. Recently* some doubt has been thrown upon the interpretation of the age of the formation. Regarding this question the following statements were made:

*American Geologist, vol. X, pp. 380-384, 1892; also Missouri Geol. Sur., vol. IV, pp. 54-55, 1894.

Marion and Pike counties, Missouri, at Hannibal, Louisiana and Clarksville principally, were the leading localities for a large proportion of the "Kinderhook" fossils originally described by Shumard, Hall, White, and Winchell. Most of these forms have a very decided Devonian aspect which gives a peculiar and characteristic physiognomy to the faunas of the three beds. Heretofore little mention has been made concerning the exact horizon of the fossils in question, mere reference to the "Lithographic" limestone, or Kinderhook beds, being considered sufficient. Lately, however, extensive collections of fossils have been made at all three places just mentioned, as well as many intervening and neighboring exposures. Everywhere the Lithographic, or Louisiana limestone has been found to be essentially devoid of organic remains, except an occasional form in the thin sandy partings above the bottommost layer, which is less than one foot in thickness. At the very base of the limestone is a thin seam of buff, sandy shale, seldom over three or four inches in thickness. This seam is highly fossiliferous. It contains the *Productella pyxidata* (Hall), *Cyrtina acutirostris* (Shumard), *Chonetes ornata* (Shumard), *Spirifera hannibalensis* (Shumard), and a host of other forms, many indistinguishable from species occurring in undoubted beds of the western Hamilton.

Lithologically, the thin sandy layer is more closely related to the underlying shales than with the overlying limestone. Faunally, it has very much nearer affinities with the western Hamilton (Devonian) than with the Kinderhook (Lower Carboniferous). In Iowa the "Devonian aspect" of the Kinderhook faunas has disappeared largely, since Calvin's recent discovery that the "Chemung" sandstones of Pine creek, in Muscatine county, Iowa, are in reality true Devonian. In Missouri the same Devonian facies of the fauna contained in the lowest member of the Carboniferous is lost from view, almost completely, by eliminating the species found in the thin sandy seam at the base of the Louisiana or lithographic limestone. The faunas of the Devonian and Carboniferous of the upper Mississippi valley thus become more sharply contrasted than ever. The apparent mingling of faunas from the two geological sections, manifestly was based upon erroneous assumptions rather than upon the detailed field evidence.

Depriving the "Lithographic" limestone, almost entirely of the extensive fauna commonly ascribed to it, and which, as has been seen, comes from a thin seam lying below the calcareous layers its geological age becomes a problem yet to be solved. The few fossils known from the limestone itself have been heretofore rarely met with. It is not at all unlikely that the lower limestone of the Kinderhook eventually may prove to be of Devonian age. But until abundant evidence to this effect is found, it seems advisable to still consider the Louisana (Lithographic) limestone as the basal member of the Carboniferous.

Since these remarks were made the organic remains which were found only in the thin basal shale (No. 6) have been obtained from higher levels, as is clearly brought out in the accompanying table. The whole formation is thus more closely related to the strata below than those above.

The Hannibal shales (Nos. 10 and 11) are almost wholly devoid of fossils in Missouri, but farther north, at Burlington,

where the beds have always been regarded as non-fossiliferous, an extensive fauna has been lately disclosed.* Its facies is very decidedly Devonian.

The thin, soft, earthy limestone (No. 12), which is nine feet in thickness at Louisiana, is believed to be the attenuated portion of the Chouteau limestone, though it is so closely associated with the lower beds of the Burlington, that it might be termed the Chouteau-Burlington. Toward the southwest the undoubted Chouteau limestone, before leaving Pike county, has a thickness of thirty feet, and still farther in the same direction in central Missouri the thickness increases to over 100 feet.

The lower Burlington limestone is separated upon lithological and faunal grounds into five zones, and the upper Burlington, as represented in the section, into three zones.

Nearly all of the strata are highly fossiliferous. The vertical section and the exposures are so extensive for a single locality that the facilities for determining the exact range of the various faunas stand unrivalled in the whole region. Moreover, a key to the stratigraphy of the entire province is furnished. Owing to unusually favorable opportunities for forming extensive collections of the fossils which are representative of the different horizons, the results are very complete. The determination of the faunal zones and their most important relationships as bearing upon the stratigraphy of the region are therefore of great interest. The subjoined tabular arrangement displays the more salient features in the distribution of the faunas.

TABLE SHOWING VERTICAL RANGE OF FOSSILS.

SPECIES.	Hudson.	Niagara.		Hamilton.		Louisiana.				Hannibal.		Chouteau.	Lower Burlington.					Upper Burlington.		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
PLANTS:																				
Plumulina gracilis (Shumard)	..		..	..	..	..	..	x	..	..	..	..	..	..	..	..	..	..	..	..
Taonurus crassus? (Hall)	..	..	..	..	..	..	..	..	..	..	x	..	..	..	..	..	..	..	..	..
SPONGES:																				
Stromatopora sp?	..	x	x	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Palæacis enormis (Meek & Worthen)	..	..	..	..	x	x	x	..	..	..	..	..	..	..	..	..	..	..	..	..
Conopterium effusum, Winchell	..	..	..	..	x	x	..	..	..	..	..	.	..	..	..	..	..	..	..	..
CORALS:																				
Amplexus blairi, Miller	..	..	..	..	..	..	..	..	..	..	..	..	..	x	x	..	..	..	..	..
Amplexus sp?	..	..	..	..	..	..	..	..	..	..	..	..	..	x	x	x	x	..	..	..

*Iowa Geol. Sur., vol. III, p. 80, 1893.

TABLE SHOWING VERTICAL RANGE OF FOSSILS—CONTINUED.

SPECIES.	Hudson.	Niagara.		Hamilton.		Louisiana.				Hannibal.		Chouteau.	Lower Burlington.					Upper Burlington.		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Amplexus fragilis, White & St. John																	x	x	x	x
Aulopora gracilis, Keyes																	x	x	x	
Chetetes sp?																			x	
Cyathophyllum sp?		x																		
Cyathophyllum sp?			x																	
Cyathophyllum sp?		x																		
Favosites sp?			x																	
Favosites favosa? (Goldfuss)			x																	
Favosites forbesi, Edw. & Haine		x	x																	
Halysites catenulatus (Linnæus)			x																	
Cleistopora typa? (Winchell)												x								
Michelinia sp?													x	x	x			x		
Monticulipora sp?	x																			
Monticulipora sp?	x																			
Monticulipora sp?	x																			
Monticulipora lycoperdon? (Say)	x																			
Stenopora sp?																		x		
Streptelasma sp?			x																	
Striatopora carbonaria, White																	x	x		
Syringopora sp?																x				
Zaphrentis acuta, White & Whitfield					x	x	x	x												
Zaphrentis calceola, White & Whitfield												x	x	x	x	x	x			
Zaphrentis centralis, Edw. & Haine																x	x	x	x	x
Zaphrentis elliptica, White													x	x	x	x	x			
Zaphrentis sp?												x	x							
Zaphrentis tantilla, Miller														x	x	x				
Zaphrentis sp?												x								
Zaphrentis sp?														x	x	x				
Hadrophyllum glans, White																	x			
ECHINODERMS:																				
Archæocidaris agassizi, Hall														x	x	x				
Actinocrinus cœlatus, Hall													x	x						
Actinocrinus clarus, Hall													x	x						
Actinocrinus glans, Hall																		x	x	x
Actinocrinus proboscidialis, Hall														x	x					
Actinocrinus scitulus, Meek & Worthen																x	x	x		
Actinocrinus verrucosus, Hall																				x
Actinocrinus obesus, Keyes																			x	x
Actinocrinus puteatus, Rowley												x	x							
Actinocrinus tenuisculptus, McChesney													x							
Actinocrinus sp?												x								
Actinocrinus sp?														x	x					
Actinocrinus sp?																		x		
Actinocrinus sp?															x					
Actinocrinus sp?																			x	x
Actinocrinus sp?																			x	x
Actinocrinus sp?														x	x					
Actinocrinus sp?														x	x					
Agaricocrinus sp?												x	x							
Agaricocrinus brevis (Hall)														x	x					
Agaricocrinus sp?														x						
Agaricocrinus bellatrema (Hall)																			x	x
Agaricocrinus americanus (Rœmer)																			x	x
Agaricocrinus gracilis (Hall)																				x
Agaricocrinus inflatus, Hall																				x
Agaricocrinus pentagonus, Hall																			x	x
Agaricocrinus planoconvexus, Hall																x	x	x		
Agaricocrinus pyramidatus, Hall														x	x					
Agaricocrinus stellatus, Hall																				x
Agaricocrinus bullatus, Hall																			x	x
Agaricocrinus sp?																			x	x
Agaricocrinus sp?																x	x			
Allagecrinus americanus, Rowley							x													
Amphoracrinus divergens (Hall)														x	x					
Amphoracrinus spinobrachiatus (Hall)														x	x					

TABLE SHOWING VERTICAL RANGE OF FOSSILS—CONTINUED.

SPECIES.	Hudson.	Niagara		Hamilton.		Louisiana.				Hannibal.		Chouteau.	Lower Burlington.					Upper Burlington.		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Barycrinus rhombiferus (Owen & Shumard)																			x	x
Batocrinus æqualis (Hall)														x						
Batocrinus æquibrachiatus (McChesney)																			x	x
Batocrinus calvini, Rowley												x								
Batocrinus christyi (Shumard)																			x	x
Batocrinus clypeatus (Hall)														x	x					
Batocrinus discoideus (Hall)													x	x	x					
Batocrinus lepidus (Hall)														x	x					
Batocrinus longirostris (Hall)												x	x	x	x					
Batocrinus quasillus, Meek & Worthen													x	x	x					
Batocrinus subæqualis (Hall)														x						
Batocrinus turbinatus (Hall)												x	x							
Batocrinus inflatus, Rowley																				
Batocrinus rotadentatus, Rowley														x	x					
Batocrinus pyriformis (Shumard)																		x	x	x
Batocrinus sp?														x	x					
Batocrinus sp?																				
Eretmocrinus carica (Hall)																x	x			
Eretmocrinus calyculoides (Hall)																				x
Eretmocrinus coronatus (Hall)														x	x					
Eretmocrinus konincki (Shumard)																			x	x
Eretmocrinus leucosia (Hall)														x	x					
Eretmocrinus verneuilanus (Shumard)																				x
Eretmocrinus sp?															x					
Eretmocrinus sp?														x						
Eretmocrinus sp?																x				
Eretmocrinus sp?												x	x	x	x					
Eretmocrinus corbulis (Hall)													x							
Eretmocrinus sp?																		x	x	
Eretmocrinus sp?																		x		
Belemnocrinus sp?																	x			
Calceocrinus ventricosus (Hall)														x	x	x		x	x	
Catillicrnus wachsmuthi, (Meek & Worthen)																		x		
Codaster kentuckiensis, Shumard																		x		
Codaster gracillimus, Rowley														x	x					
Codaster grandis, Rowley																		x		
Codaster sp?												x	x							
Orophocrinus stelliformis (Shumard)															x					
Orophocrinus inopinatus, Rowley												x	x	x						
Cyathocrinus sp?																		x	x	
Cyathocrinus sp?																				x
Cyathocrinus iowensis (Owen & Shumard)																x	x			
Cyathocrinus sp?															x					
Cyathocrinus sp?							x													
Dichocrinus lineatus, Meek & Worthen																			x	x
Dichocrinus pisum, Meek & Worthen																		x	x	x
Dichocrinus plicatus, Hall																			x	x
Dichocrinus striatus, Owen & Shumard																				x
Dichocrinus sp?														x	x					
Dichocrinus sp.														x	x					
Dorycrinus parvus (Shumard)																			x	x
Dorycrinus intermedius, Meek & Worthen																			x	x
Dorycrinus rœmeri, Meek & Worthen																				x
Dorycrinus cornigerus (Hall)																				x
Dorycrinus subaculeatus (Hall)														x						
Dorycrinus unicornis (Owen & Shumard)												x	x	x	x	x				
Dorycrinus missouriensis (Shumard)																			x	x
Dorycrinus inflatus, Rowley												x								
Dorycrinus sp?																			x	
Glyptocrinus fornshelli, Miller	x																			
Glyptocrinus sp?		x																		

TABLE SHOWING VERTICAL RANGE OF FOSSILS—CONTINUED.

SPECIES.	Hudson	Niagara.		Hamil'ton.		Louisiana.				Hannibal.		Chouteau.	Lower Burlington.					Upper Burlington.		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Gilbertsocrinus sp?																				x
Gilbertsocrinus tuberculosus (Hall)																			x	x
Gilbertsocrinus obovatus (Meek & Worthen)																				x
Cryptoblastus melo (Owen&Shumard)												x	x	x	x	x				
Granatocrinus granulosus, Meek & Worthen																				x
Granatocrinus norwoodi (Owen & Shumard)																				x
Granatocrinus projectus (Meek & Owen)														x	x					
Granatocrinus pisum (Meek & Worthen)														x	x					
Granatocrinus aplatus, Rowley																	x			
Granatocrinus magnibasis, Rowley																		x		
Granatocrinus concinnulus, Rowley														x	x					
Granatocrinus sp?																				x
Granatocrinus sp?																	x	x		
Schizoblastus sayi (Shumard)																		x	x	
Graphiocrinus sp?														x						
Ichthyocrinus burlingtonensis, Hall																x				
Ichthyocrinus sp?												x								
Megistocrinus evansi (Owen & Shumard)													x	x	x					
Pentremites e'ongatus, Shumard																				x
Physetocrinus ornatus (Hall)														x						
Physetocrinus venticosus (Hall)																		x	x	x
Physetocrinus sp?																		x		
Platycrinus americanus, Owen & Shumard															x					
Platycrinus asper, Meek & Worthen																				x
Platycrinus burlingtonensis, Owen & Shumard														x						
Platycrinus cavus, Hall																				x
Platycrinus corrugatus, Owen & Shumard															x					
Platycrinus disoideus, Owen & Shumard														x	x					
Platycrinus excavatus, Hall															x					
Platycrinus halli, Shumard																				x
Platycrinus incomptus, White																				x
Platycrinus perasper, Meek&Worthen															x					
Platycrinus pileiformis, Hall														x	x					
Platycrinus planus, Owen & Shumard												x	x	x	x					
Platycrinus pocilliformis, Hall														x	x					
Platycrinus regalis, Hall															x					
Platycrinus scobina, Meek & Worthen															x					
Platycrinus subspinosus, Hall													x	x						
Platycrinus altidorsatus, Rowley																				x
Platycrinus corbuliformis, Rowley												x								
Platycrinus marginatus, Rowley																	x			
Platycrinus pisum, Rowley														x	x					
Platycrinus planobasalis, Rowley																		x		
Platycrinus lautus, S. A. Miller												x								
Platycrinus sp?												x								
Platycrinus sp?												x								
Poteriocrinus sp?																		x	x	
Poteriocrinus waltersi, Rowley												x	x							
Poteriocrinus sp?																			x	x
Rhodocrinus barrisi, Hall																			x	x
Rhodocrinus wachsmuthi, Hall																x	x			
Rhodocrinus whitei, Hall												x	x							
Rhodocrinus wortheni, Hall														x	x					
Saccocrinus amplus, Meek & Worthen																				x
Steganocrinus araneolus, (Meek & Worthen)															x	x				
Steganocrinus concinnus, Shumard																		x	x	x

TABLE SHOWING VERTICAL RANGE OF FOSSILS—CONTINUED.

SPECIES.	Hudson.	Niagara.		Hamilton.		Louisiana.				Hannibal.		Chouteau.	Lower Burlington.					Upper Burlington.		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Steganocrinus pentagonus (Hall)															x	x				
Steganocrinus sculptus (Hall)															x	x	x			
Strotocrinus glyptus (Hall)																			x	x
Strotocrinus regalis (Hall)																		x	x	x
Symbathocrinus brevis, Meek & Worthen														x						
Symbathocrinus dentatus, Owen & Shumard																		x	x	
Symbathocrinus papillatus, Owen & Shumard																		x	x	
Symbathocrinus wortheni, Hall																		x	x	
Symbathocrinus sp?																		x		
Symbathocrinus sp?															x					
Taxocrinus themii (Hall)														x						
Teleiocrinus ægilops (Hall)																			x	x
Teleiocrinus liratus (Hall)																			x	x
Teleiocrinus umbrosus (Hall)																				x
Teleiocrinus sp?																x				
Metablastus wortheni (Hall)?																				x
Metablastus lineatus (Shumard)														x	x					
Metablastus sp?																				x
Woodocrinus elegans (Hall)																	x			
Woodocrinus troostanus, Meek & Worthen																x	x			
Woodocrinus sp?																	x	x		
BRYOZOANS:																				
Coscinium latum, Ulrich														x						
Evactinopora grandis, Meek & Worthen														x	x					
Evactinopora radiata, Meek & Worthen															x					
Evactinopora sexradiata, Meek & Worthen																	x			
Fenestella burlingtonensis, Ulrich																		x	x	x
Fenestella filistriata, Ulrich														x	x					
Leioclema sp?					x	x														
Lyropora retrorsa, Meek & Worthen															x					
Polypora burlingtonensis, Ulrich														x	x					
Rhombopora sp?														x						
Tæniodictya ramulosa, Ulrich																			x	x
BRACHIOPODS:																				
Ambocœlia minuta, White						x	x	x												
Ambocœlia sp?														x	x					
Athyris incrassata, Hall																x	x		x	x
Athyris lamellosa, Hall												x	x	x	x	x	x			
Athyris sp?																				x
Athyris hannibalensis, Swallow					x	x	x				x	x								
Athyris sp?														x	x					
Athyris sp?														x	x					
Atrypa nodostriata Hall,			x																	
Atrypa sp?		x																		
Camarophoria sp?															x	x	x			
Centronella rowleyi (Worthen)														x	x					
Centronella sp?														x	x					
Chonetes geniculatus, White						x	x													
Chonetes logani, Norwood & Pratten														x	x					
Chonetes ornatus, Shumard					x	x	x				x									
Chonetes sp?															x					
Crania rowleyi, Gurley						x	x													
Crania sp?						x														
Crania sp?						x														
Crania sp?														x						
Cyrtina acutirostris, Shumard					x	x	x	x												
Cyrtina burlingtonensis, Rowley														x	x					
Discina sp?					x	x														
Discina melie, Hall														x						

TABLE SHOWING VERTICAL RANGE OF FOSSILS—CONTINUED.

SPECIES.	Hudson.	Niagara.		Hamilton.		Louisiana.				Hannibal.		Chouteau.	Lower Burlington.					Upper Burlington.		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Eumetria prima? White														x	x					
Leiorhynchus? sp?															x					
Leptæna sericea, Sowerby	x																			
Lingula sp?				x																
Lingula sp?				x																
Lingula halli? White														x						
Meristella sp?		x																		
Nucleospira barrisi? White							x	x												
Nucleospira sp?														x	x					
Platystrophia acutilirata (Conrad)	x																			
Rhipidomella missouriensis (Swallow)					x	x	x				x									
Orthis elegantula? Dalman		x																		
Orthis flabellulum, Sowerby			x																	
Orthis sp?			x																	
Orthis occidentalis, Hall	x																			
Orthis subquadrata, Hall	x																			
Orthis swallovi, Hall												x	x	x	x	x	x	x	x	
Orthis testudinaria, Dalman	x	x	x	x																
Orthis sp?														x	x					
Orthis burlingtonensis, Hall													x	x	x				x	x
Productella pyxidata (Hall)					x	x	x	x	x		x									
Productella shumardiana, Hall														x						
Productella sp?														x						
Productus arcuatus, Hall														x	x					
Productus cora? d' Orbigny														x	x	x	x			
Productus burlingtonensis, Hall														x	x	x	x			
Productus punctatus, Martin														x	x					
Productus semireticulatus, Martin																x	x		x	
Productus viminalis, White														x	x					
Productus sp?														x	x	x				
Productus sp?												x	x	x						
Productus sp?														x	x					
Productus sp?														x	x					
Retzia? sp?															x					
Retzia? sp?															x					
Retzia? sp?						x	x													
Rhynchonella boonensis, Swallow															x	x	x			
Rhynchonella capax, Conrad	x																			
Rhynchonella missouriensis, Shumard					x	x	x													
Rhynchonella sp?														x	x					
Rhynchonella sp?														x	x					
Rhynchonella sp?														x	x					
Rhynchonella whitei? Winchell		x																		
Rhynchonella sp?			x																	
Spirifera forbesi, Norwood & Pratten													x	x	x					
Spirifera hirtus, White & Whitfield														x	x					
Spirifera imbrex, Hall																x	x			
Spirifera incerta, Hall														x	x					
Spirifera lineatoides, Swallow														x	x					x
Spirifera marionensis, Shumard					x	x	x				x									
Spirifera meeki, Swallow															x					
Spirifera peculiaris? Shumard														x	x	x				
Spirifera plena, Hall																				x
Spirifera pseudolineata, Hall																				x
Spirifera solidorostris, White														x	x					
Spirifera striatiformis, Meek													x	x	x	x				
Spirifera subrotundata, Hall																				x
Spirifera grimesi, Hall												x	x	x	x	x	x	x	x	x
Spirifera temeraria? Miller														x	x					
Spirifera mundula, Rowley														x	x					
Spirifera sp?														x	x					
Spirifera sp?																			x	x
Spiriferina binacuta, Winchell														x	x					
Spiriferina clarksvillensis, Winchell						x	x	x												
Spiriferina aciculifera, Rowley						x	x								x					
Spiriferina subtexta, White															x					

TABLE SHOWING VERTICAL RANGE OF FOSSILS—CONTINUED.

SPECIES.	Hudson.	Niagara.		Hamilton.		Louisiana.				Hannibal.		Chouteau.	Lower Burlington.					Upper Burlington.		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Streptorhynchus crenistriatus? Phillips																	x		x	
Streptorhynchus filitextum? Hall	x																			
Streptorhynchus lens (White)					x	x	x													
Streptorhynchus planumbonum (Hall)	x																			
Streptorhynchus subplanum (Conrad)		x	x	x																
Streptorhynchus sp?			x																	
Strophalosia scintilla, Beacher						x	x													
Strophalosia beecheri, Rowley						x														
Strophomena alternata, Conrad	x																			
Strophomena rhomboidalis, Wilkens		x	x																	
Strophomena rhomboidalis var														x	x	x	x	x		
Syringothyris typus, Hall													x	x	x	x	x			
Syringothyris carteri (Hall)					x	x	x	x			x									
Terebratula burlingtonensis, White														x	x	x				
Terebratula sp?														x	x					
Terebratula sp?														x						
Terebratula sp?						x	x				x									
Terebratula sp?						x	x													
Zygospira putilla, Hall		x																		
Zygospira recurvirostra, Hall	x																			
LAMELLIBRANCHS:																				
Aviculopecten burlingtonensis, Meek & Worthen														x	x					
Aviculopecten circulus, Shumard														x						
Cardiomorpha sp?															x					
Cardiopsis sp?														x						
Conocardium sp?														x						
Crenipecten sp?														x	x					
Crenipecten sp?															x					
Cypricardella sp?														x						
Cypricardia sp?															x					
Dexiobia sp?											x									
Edmondia burlingtonensis, White & Whitfield														x						
Edmondia nuptialis, Winchell														x						
Grammysia hannibalensis (Shumard)						x					x									
Nuculites sp?														x						
Pernopecten cooperensis (Shumard)											x									
Pernopecten sp?															x					
Prothyris meeki, Winchell															x					
Sanguinolaria sp?															x					
Sanguinolites burlingtonensis, Worthen														x	x					
Sanguinolites sp?											x									
Sanguinolites sp?							x													
Sphenotus sp?														x						
Lithophaga occidentalis, White & Whitfield														x						
PTEROPODS:																				
Conularia sp?	x																			
Conularia sp?							x													
Conularia victa? White															x					
Tentaculites sp?			x																	
GASTEROPODS:																				
Bellerophon sp?		x																		
Bellerophon bilabiatus, White & Whitfield														x	x					
Callonema sp?					x	x														
Cyclonema sp?		x	x																	
Cyrtolites sp?		x																		
Dentalium sp?															x					
Planerotinus paradoxus, Winchell														x						
Omphalotrochus springvalensis (White)														x	x					
Straparollus latus, Hall												x	x	x	x	x	x			
Straparollus ammon (White & Whitfield)														x	x					

TABLE SHOWING VERTICAL RANGE OF FOSSILS—CONTINUED.

SPECIES	Hudson.	Niagara.		Hamilton.		Louisiana.				Hannibal.		Chouteau.	Lower Burlington.					Upper Burlington.		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Straparollus roberti, White															x					
Straparollus obtusus, Hall														x						
Straparollus sp?															x					
Loxonema delphicola (Hall)														x	x					
Loxonema prolixa, White & Whitfield														x	x					
Soleniscus sp?															x					
Soleniscus sp?														x	x					
Sphærodoma penguis (Winchell)														x						
Murchisonia pygmaea, Rowley							x	x												
Murchisonia sp?														x						
Murchisonia sp?		x																		
Murchisonia sp?		x																		
Igoceras quincyense (McChesney)												x	x							
Igoceras capulus (Hall)															x	x				
Capulus latus (Keyes)													x	x						
Capulus paralius (Keyes)														x						
Capulus biserialis (Hall)																			x	
Capulus ooliquuas (Keyes)													x	x						
Capulus tribulosus (White)																				x
Capulus sp?														x						
Capulus sp?						x	x													
Orthonychia formosus (Keyes)														x						
Orthonychia pabuliformis (Owen)															x	x	x	x	x	
Strophostylus reversus (Hall)																			x	x
Pleurotomaria sp?		x																		
Pleurotomaria sp?		x																		
Pleurotomaria minima, Rowley							x	x												
Pleurotomaria subcarbonaria, Keyes														x	x					
Pleurotomaria sp?														x	x					
Pleurotomaria sp?														x	x					
Pleurotomaria montezuma, Worthen																x				
Holopea subconica? Winchell														x						
Porcellia nodosa, Hall														x						
CEPHALOPODS:																				
Cyrtoceras sp?														x						
Goniatites sp?																				
Goniatites sp?														x	x					
Goniatites osagensis, Swallow														x						
Goniatites sp?																				x
Goniatites sp?							x	x			x									
Goniatites louisianensis, Rowley							x													
Nautilus sp?														x						
Orthoceras sp? Hall		x																		
Orthoceras sp?			x																	
Orthoceras sp?														x						
Orthoceras sp?															x					
Orthoceras sp?														x						
WORMS:																				
Cornulites carbonarius, Gurley						x	x													
Spirorbis kinderhookensis, Gurley						x	x													
CRUSTACEANS:																				
Asaphus megistos (Locke)	x																			
Calymene callicephala, Green	x																			
Calymene niagarensis, Hall		x	x																	
Dalmanites sp?		x																		
Lichas sp?			x																	
Phillipsia swallovi? Shumard						x														
Phillipsia insignis, Winchell														x	x					
Phillipsia tuberculata, Meek & Worthen														x	x	x	x	x		
Phillipsia sp?														x						
VERTEBRATES:																				
Fish teeth															x	x	x			
Fish teeth and bones				x	x															
Fish spine					x															

The above table embraces all the evidence thus far obtained at the locality in question.

In considering the faunal features of the succession the interest centers in the characters of the fauna of the Kinderhook and of its several parts. Three problems are presented: (1) the general facies of the fauna as a whole, and the parts giving it its predominant phase; (2) the character and relations of the basal fauna, and (3) the upper limit, if any can be made out, of the fauna most characteristic of the formation.

(*1*) *General Faunal Facies.*—Heretofore the attempt has been always to treat the organic remains contained in the Kinderhook, "Chouteau" or "Chemung," as belonging to a single fauna. Owing to the heterogeneous beds that have been placed together in the formation it has been the chief mission of later work to take out from time to time various parts which were originally correlated with this terrane. Thus gradually the formation at its typical localities has finally come to be more clearly understood.

Regarding the "Kinderhook" as made up of three subdivisions, the Louisiana limestone, the Hannibal shale and the Chouteau limestone (in its original sense) the fauna contained when deprived of elements which have in reality no relation to it whatever, presents a very different facies from that generally ascribed to it. With the light of definite zonal distribution of the organic forms there appears to be, instead of a single compact and characteristic group of forms, two very distinct faunas, as is nowhere more clearly shown than in the locality which can be regarded as typical and in which the faunal zones have been determined with considerable accuracy and corroborated by evidence from other districts. Owing to indefinite knowledge regarding the exact horizons from which the various genera and species have been found in the past the general faunal facies of the "Kinderhook" has heretofore borne a composite and not a pure physiognomy.

A tabular arrangement of all the species of fossils that are recognized at a typical locality for the Kinderhook, and that range from the Hudson to the Upper Burlington, has disclosed very clearly some important facts which heretofore have been overlooked. The first of these features is the close affinity of the faunas, from the lower two members of the Kinderhook, with the underlying Devonian, and the second is the sharpness with which the lower fauna stops at the base of the Chouteau,

and the abruptness with which an entirely new fauna begins at that level.

(2) Character and Relations of the Lower Fauna.—The components of this fauna comprise those forms which, as already noted, occur in the Louisiana limestone and the Hannibal shales. For the present only the species from the former need occupy attention.

As a whole the fauna is clearly closely related to that occurring in the Western Hamilton. Some of the species, though bearing different names, are in reality identical with typical forms from that formation. Heretofore the fossils have been found, with few exceptions, perhaps, only in the basal portion of what is called the Louisiana limestone, in number 6, a thin sandy layer which is lithologically similar to the partings in the limestone itself. The results of the latest investigatons show that many of the forms extend upward, some of them passing practically unchanged through the whole Louisiana to the top of the Hannibal. Not a single species of this fauna appears to occur in the overlying layer which has been regarded as the equivalent of the Chouteau. Many of the forms also range downward into the dark colored shale below, which is regarded as of Devonian age and which is here separated into two parts. A short distance away the shale becomes much thicker.

The general impression derived from the table is that the zones 5 to 8 inclusive are faunally very closely related, and that the higher ones, 9 to 11, also have close affinities with the lower zones. It may be noted in this connection that no special effort has been made to determine the full faunas of the higher beds, as the critical evidence that was needed was in regard to the fauna of the Louisiana (Lithographic) limestone. The shales have, however, proved to be remarkably barren in organic remains. Towards the top where they become sandy a number of the lower species are found. That the shales do not appear to be fossiliferous is not remarkable. Since they manifestly do not contain abundant remains in a good state of preservation they have not been searched so carefully by fossil collectors as have the other beds. At Burlington, Iowa, where there are excellent exposures and numerous active local collectors, besides a host of transient ones, the same shales remained for half a century without a fauna to be ascribed to them. But of late they have been shown to be abundantly

supplied with fossils. Without exception they appear to be characteristic Devonian forms. As yet, however, the fauna has not been studied sufficiently to be specifically listed, but the brachiopods are mostly very similar to, if not identical with, the species found in undoubted Devonian shales farther northward in the same state. The cephalopods are represented by large forms of Cyrtoceras, Gomphoceras, and Phragmoceras. One belonging to the latter genus may prove to be Winchell's *P. expansus*. Another very characteristic phase of the fauna is the non-trilobitic crustaceans, of which a very considerable number have been found. They have very close affinities to Tropidocaris and Amphipeltis.

It appears, then, that a well defined Devonian fauna extends up to the top of the Hannibal shales in northeastern Missouri, at Louisiana especially, and that the "Kinderhook" shales of southeastern Iowa, as typically developed at Burlington, and as corresponding in great part to the Hannibal shales, carry no other remains than those of pronounced Devonian types. The upper part of the section usually regarded as Kinderhook at Burlington, in fact all the thin limestone and sandstone bands down to the great body of argillaceous shales may be more properly regarded as the equivalent of the Chouteau limestone, that is, the uppermost member of the so-called Kinderhook in Missouri.

(3) *Upper Limit of the Louisiana Fauna.*—One reason that the fauna of the Chouteau (original) limestone has not been better understood than it has, in its relation to the faunas occurring lower in the so-called Kinderhook, and higher in the Burlington limestone, has been that in the localities where the lower Carboniferous has been most thoroughly and widely studied along the Mississippi river, the Chouteau, as commonly recognized, nowhere crops out along the great stream, except, perhaps, in the vicinity of the town of Louisiana where, under the typical Burlington, there are nine feet of earthy limestone which has been considered a part of the latter, but which is now believed to be the attenuated edge of the Chouteau, or its equivalent. In the same county the Chouteau attains a maximum thickness of twenty-five to thirty feet.

In the table given there is: (1) The species that come up from below to the base of the Chouteau, (2) those starting in the Chouteau and ranging upward, (3) the forms starting in the basal member of the Burlington limestone, and (4) the

species which comprise a lower fauna in the midst of a higher.

The most striking features in the vertical distribution of the fossils shown in the table given are: (1) The upper fauna nowhere extends beneath the base of the Chouteau (No. 12) and the lower fauna nowhere rises above the same line; (2) all the species belonging to the fauna beginning in the Chouteau extend upward into the Burlington; (3) while in the Burlington many new forms appear there is no immediate replacement of the older forms; (4) the many new species which appear in the second bed of the Burlington (No. 14) are largely so-called Kinderhook forms, not altogether from the Chouteau, but from the limestones which occur just beneath the Burlington limestone at the city of Burlington.

From a consideration of both tabular arrangements the following general conclusions are deduced:

1. The most marked change in the succession of faunas in the entire sequence of rocks commonly known as the Lower Carboniferous, or "Subcarboniferous" as represented along the Mississippi river is at the base of the Chouteau limestone (limited). At this horizon there is so great a faunal hiatus that there is scarcely a species that is common to the beds on either side.

2. That instead of the so-called Kinderhook containing in its fauna a mingling of Devonian and Carboniferous types there are really two faunas that are perfectly distinct, well-defined and not merging into each other. The one is characteristically Devonian in character and the other as strikingly Carboniferous in its general facies.

3. That the basal line of the Lower Carboniferous or Mississippian series is the base of the Chouteau limestone and the lower member of the four-fold series contains only one formation instead of the three heretofore commonly ascribed to it.

4. That the early reference of a part of the so-called Kinderhook or "Chemung" to the Devonian was correct in fact, though made through erroneous correlations.

5. That the evidence afforded by the faunas of the region is in close accord with the facts obtained regarding discordant sedimentation, and the stratigraphical and lithological characters of the formations.

NATURAL GAS IN THE DRIFT OF IOWA.

BY A. G. LEONARD.

The finding of natural gas in the Pleistocene deposits of the state has been noted from time to time during the past decade. The first mention of its occurrence, as far as known, appeared in the report of the state mine inspector* for the years 1886 and 1887.

A brief account is therein given of its discovery at Herndon, Guthrie county, in 1886, while boring a hole for water. Six wells are reported as yielding a good flow of gas, which was utilized for cooking and heating purposes. The presence of gas at Herndon is also mentioned by McGee in the Eleventh Annual Report of the United States Geological Survey.† In the proceedings of the Iowa Academy of Sciences for 1890–1891 Mr. F. M. Witter‡ reports the discovery of natural gas near Letts, Louisa county. Seven wells sunk for water yielded it, and the gas from one furnished fuel and light for four families. Its probable source is stated to be from the vegetable matter buried in the drift.

R. Ellsworth Call in the Monthly Review of the Iowa Weather and Crop Service for November, 1892,§ reports that there are many instances of the discovery of natural gas in the drift of the state while exploring for coal or for artesian waters. The wells at Herndon and Letts are noted as are also those at Dawson, in Dallas county.

In all cases the gas is thought to have come from the vegetable debris of the glacial deposits.

Among the other localities where this natural fuel has been found may be mentioned one about seven miles northeast of Des Moines and another not far from Stanhope, in Hamilton county. For several years gas from the well at the latter place has been utilized for fuel.

*Report state mine inspector, 1887, pp. 169-170.
†Eleventh Ann. Rept., 1889-1890, part I, p. 595.
‡Iowa Acad. Sci., vol. I, part II, pp. 68-70.
§Monthly Rev. Iowa Weather and Crop Serv., vol. III, Nov., 1892, p. 6-7.

From the above it will be seen that the occurrence of natural gas in the glacial deposits of the state is not an uncommon event and that a number of different localities have yielded it in small amounts.

Before taking up the subject of the source and origin of the natural gas it will be well to describe more in detail some of the localities mentioned above, in order that the conditions under which the gas is found may be clearly in mind. Only after such a careful review of the facts connected with the various occurrences is it possible to form an opinion as to the probable source. A comparison of the Iowa localities with those of other states will also prove helpful in this connection.

The Herndon wells were the first in the state, so far as known, to yield gas in any considerable amount. Its discovery is thus described in the mine inspector's report already referred to: In the month of October, 1886, Mr. G. Gardner was boring a hole for water and had reached a depth of about 120 feet. Work had been stopped for the night and the family was at supper when suddenly a loud noise was heard like that made by steam escaping from a boiler, and on going out to the well it was found discharging large quantities of gas, sand and gravel. This first well was not used on account of the difficulty experienced in getting it tubed so as to shut out the sand. A second was abandoned for the same reason, but the third, put down by by Mr. H. C. Booth, was more successful. The gas was conducted into the house and used for heating and cooking purposes. Six wells have been bored here and a good strong flow obtained in all of them. In two of these the flow still continues but the others have become choked up with sand. The depth of the wells varies from 120 to 140 feet. The gas is found in a layer of sand and above this the following beds occur:

	FEET.
Black loam	6
Yellow clay	6
Blue clay	108

One well at this locality is reported to have reached a depth of over 219 feet and went a considerable distance into the coal measures, but it yielded no gas. Another well, which for a time had a good flow of gas, was located near the town of Yale, five miles south of Herndon.

The only direct evidence of any considerable accumulations of vegetable material in the drift of this region is furnished by

the record of an old water well near Yale, where a forest bed some three feet in thickness was passed through. It was overlaid by forty-two feet of yellow, blue and red clay and beneath was four or five feet of blue clay. Below the latter there is from two to ten feet of sand. The gas at Herndon is found in a layer of sand at the base of the drift and probably directly overlying the coal measure shales.

During the past summer the wells near Dawson were visited and a few additional facts secured concerning them. Dawson is located near the northern border of Dallas county and about eight miles east of Herndon. The wells are three-quarters of a mile south of town and the gas occurs under much the same conditions as at the locality already mentioned. Five holes have been drilled here, one being put down in 1888 and the other four in 1891. They have a depth of from 110 to 115 feet, passing through the drift clay into a bed of sand and gravel. The gas is found in the gravel layer below a compact blue clay. A coal shaft just east of Dawson shows sixty-four feet of this blue clay. During the past summer the first well, bored eight years ago, was tested to find the pressure, the result being that this was ascertained to be 24 to 25 pounds to the square inch. The gas burned with a flame 15 to 20 feet high. It was piped to town, and for a time supplied one of the houses with fuel. It was also used in the kilns of a brick plant a short distance east of the station. Three of the wells still have a good flow but are no longer used.

In this connection mention should perhaps be made of the gas found in considerable quantity in the water supply of Perry, six miles east of Dawson. Perry secures its supply from four wells located in the southern part of town. These wells have a depth of 115 feet. Gravel is struck 70 feet below the surface and the lower 45 feet is through this material. The water for a time came to the surface and overflowed, but after a number of wells were sunk and it had been pumped from the city wells the head was lowered, and now the water rises only to within 5 or 6 feet of the surface. The amount of gas in the water is so great that Mr. J. W. Rodefer has for some time been experimenting for the purpose of extracting it for use in heating and lighting. He has succeeded in doing this on a comparatively small scale, and the gas thus separated is utilized to furnish fuel and light to his office. Can it be extracted by a sufficiently inexpensive method, and in large enough quantity,

this natural gas contained in its water supply may yet furnish Perry with a convenient fuel.

In the case of the wells near Letts, Louisa county, the conditions appear to be slightly different. They have a depth ranging from 90 to 125 feet, but do not reach the base of the drift, since in a number of instances the rock in this region has not been struck at 280 feet below the surface. "At a depth of from 6 to 25 feet below the gas a good, constant supply of water is obtained. It seems to be very easy to shut off the gas by the rapid sinking of the casing in a sort of blue clay with some sand, in which the gas is thought to be stored. The clay seems to form a tube as the drill and casing descend, and this prevents the gas from getting into the well unless it is given a little time at the right place. The country for miles around is full of wells which are all believed to be sunk to the water below the gas, without discovering the latter for reasons given above." From the foregoing statements it is apparent that the gas at this locality does not occur in a well defined sand bed, but is distributed through the upper portion of the Pleistocene deposits, being usually found at a depth of about 100 feet. There seems to be abundant evidence of the presence of extensive accumulations of vegetable material in the drift of this region.

But Iowa is not the only state where natural gas is found in the surface deposits, for it occurs also in the drift of Ohio, Indiana and Illinois. Its occurrence in Ohio is mentioned by Orton.* On the southern margin of the drift of that state and for twenty to forty miles back from its border there are in many parts of the state considerable accumulations of vegetable matter covered by later deposits of the drift period. Wells dug into these deposits often strike quite extensive accumulations of one or the other of the two gases given off by the decomposition of this buried vegetation, namely, carbon dioxide and marsh gas. Sometimes carbon dioxide, or carbonic acid gas as it is commonly called, is found in all the wells of the neighborhood and no water well can be completed on account of its presence. It is not an uncommon thing for well diggers to lose their lives from this deadly "choke damp."

Calvin has noted several instances in Iowa where this gas escaped with considerable force from holes bored for water.

*Geol. Surv. of Ohio, vol. VI, pp, 772-775.

Much more frequently marsh gas is struck in the vegetable deposits (of Ohio) and sometimes escapes in large volume and with great force when first released. It not infrequently gives rise to a small but persistent supply. Gas wells are of common occurrence in all the border areas above mentioned.

In Illinois natural gas in the drift has been found in commercially valuable quantities at Bloomington, Kankakee, Mendota, and other points.

The reports of the Indiana survey also contain accounts of the discovery of gas in the superficial deposits of that state.

From what has been said above it will be seen that it is by no means an uncommon thing to find gas in the Pleistocene deposits. It has been discovered at a number of different points in at least four states and doubtless there are unrecorded occurrences in other parts of the country.

We are now prepared to consider the question as to the source of this natural gas and later its origin.

There are two possible sources of the gas found in the drift. (1) It may have been derived from the underlying rock and the drift then serve simply as a reservoir for its accumulation and storage, or (2) it may have been derived from the vegetable accumulations of the drift and thus have its source in the Pleistocene deposits where it is now found. The latter source is doubtless much the more common and in most instances there is little doubt that the gas has been derived from the decomposition of the vegetable remains in the drift. But examples of the drift serving as a reservoir only, are occasionally found. Thus, Orton mentions several such instances in Ohio and it is possible, though hardly probable, that at Herndon and Dawson the gas has been derived from the underlying coal measures shales.

That it may have such a source the gas-bearing rocks must be overlaid by porous beds of drift. Then during the long periods since they have had this relation the porous beds have become charged with gas when there were suitable conditions of level. As we have already seen the arrangement of the beds at Herndon and Dawson are such that it is possible that the gas might be derived from the rocks underlying the drift sheet. At both of these localities the gas occurs in a stratum of sand and gravel at the base of the drift and apparently directly overlying the coal measures. As already stated the wells have a depth

of from 110 to 140 feet. Nowhere in this immediate neighborhood is the drift known to have a greater depth than this. At Dawson a coal shaft shows the superficial deposits to be eighty feet thick at that point. At Angus, a few miles northeast of Dawson, there is a thickness of fifty to 100 feet and in southern Greene county borings show between sixty and seventy feet of drift. There seems to be considerable evidence, therefore, that the gravel is at the base of glacial deposits and that it rests directly on the coal measure shales. In this case it would be possible that the gas, originating in these black carbonaceous shales, may have passed up into and accumulated in the gravel and sand beds above.

But it seems much more probable that the gas at Herndon and Dawson has its source in the vegetable accumulations of the drift, as is undoubtedly true for the gas at Letts.

It is not necessary to suppose that it has been formed directly in the place where it is now found. It may have originated from the decomposition of vegetable material some considerable distance off and later have diffused itself laterally through the gravel beds until reaching a place favorable for its accumulation.

There is another interesting fact concerning the distribution of these gas wells. They are found not far from the border of the upper drift sheet of the region. Thus, for example, at Dawson and Herndon the wells are only a few miles back from the edge of the Wisconsin lobe and at Letts the Illinois ice seems to have extended but a short distance in the west. Orton mentions the same fact concerning the distribution of wells in Ohio, where as already stated, they are found along the border of the glacial deposits or back twenty to forty miles.

The most favorable conditions for the preservation of forest beds and like accumulations of vegetable material would seem to be near the edge of the ice, where it was the thinnest, and where, during its advance, there would have been less disturbance of the materials beneath. During its advance only a comparatively few miles of the ice sheet would pass over the drift near its border, while back 50 or 75 miles the ice would doubtless be considerably thicker and a vastly greater amount of ice would pass over the surface, and as a result the underlying deposits would be more disturbed. The forest bed, if present, might be carried away or mingled with the clay of the drift.

Concerning the origin of natural gas little need be said. It is now generally admitted by all geologists and most chemists

that the various bitumens, including natural gas, are genetically connected with and are closely allied to marsh gas, and that they are produced by the natural decomposition of organic tissue. Natural gas closely resembles in composition the inflammable marsh gas which is often observed coming from the muddy bottoms of stagnant ponds. The following analysis, giving the mean results of seven analyses made for the United States Geological survey by Prof. C. C. Haward, will show the composition of natural gas:

Marsh gas	93.36
Nitrogen	3.28
Hydrogen	1.76
Carbon monoxide	.53
Oxygen	.29
Olefiant gas	.28
Carbon dioxide	.25
Hydrogen sulphide	.18
Total	100.03

Marsh gas, the principal constituent, is a simple compound of carbon and hydrogen in the proportions of 75 per cent of the former to 25 per cent of the latter.

The natural gas of the Pleistocene deposits of Iowa is then simply the product of the decomposition of the vegetable remains buried in the drift.

RESULTS OF RECENT GEOLOGICAL WORK IN MADISON COUNTY.

BY J. L. TILTON.

OUTLINE.

1. The geological formations of the county.
2. The distribution of the alluvium, loess and drift.
3. The relation of present drainage to preglacial drainage.
4. Terraces.
5. The areas occupied by the Des Moines and Missourian stages of the coal measures.
6. The transition from the Des Moines to the Missourian stage.

It is intended in this paper to state briefly some of the geological features of Madison county as observed during the

past summer. For a more detailed description, reference may be made to the complete report in the next volume of the "Iowa Geological Survey."

The county is thoroughly drained, the uplands well dissected by ravines that have left no swamps. The streams have well established grades over loess and drift. Only at the heads of smaller ravines is present erosion still in progress. Such a drift topography is again approaching maturity.

Above the flood plains of the streams a line of low, rounded knolls rises about six feet. These constitute a river terrace in the normal development and mark the highest limit of spring floods. About fifty feet above the bed of Middle river the remains of a second terrace are found in various places along the stream. At various points terrace-like places appear along the hillsides. Some of these are undoubtedly dependent on the resistant character of underlying strata. As a whole they bear so little relation one to another and to the river bed, that they are judged not to be terraces dependent on former stages of water in the stream, but of local character dependent on the differential weathering of the hillsides.

The geological formations of the county are given in the following table:

CLASSIFICATION OF FORMATIONS IN MADISON COUNTY.

GROUP.	SYSTEM.	SERIES	STAGE.	SUBSTAGE.
Cenozoic.	Pleistocene.	Recent.		Alluvium.
		Glacial.	Iowan.	Loess.
			Kansan.	Drift.
Paleozoic.	Carboniferous	Upper.	Missourian. Represented by the Winterset limestone.	
			Des Moines.	

Alluvial deposit is to be found in the broad river valleys. It generally lies on loess extending down into the river bottoms.

The loess deposit of the county occupies the divides, and extends over the hillsides into the river valleys. It is quite thin over the entire county, excepting east of Barney, where large hills of loess are banked against the adjacent Missourian limestone. The loess here is stratified, seeming to be made up of wash from the unstratified loess. In the east central and northeastern parts of the county the loess is more sandy than as usually found. The loess consists of two parts, an upper and a lower; the lower is more clayey than the upper, but no soil line has been observed between the two parts within the bounds of the county. The line between the two may have some relation to the soil line first observed at Churchville, Warren county, by Bain, and to the line of separation between the upper and lower loess at Indianola described in the report on the "Geology of Warren county."*

The Kansan drift is very heavy in the northeastern, southeastern and southwestern parts of the county. It consists of the usual reddish-brown gravel containing subangular waterworn pebbles of various light colored granite and quartz, together with greenstone and reddish quartzite pebbles and boulders. Below this gravel is a clay with numerous pebbles scattered through it, that, under the action of running water, form numerous little pot-holes in the beds of ravines that cut into this clay in the southeastern part of the county. There are no characteristics at present known whereby the relation of this lower part of this Kansan drift to the sub-Aftonian, or Albertan, drift may be determined.

There is no Wisconsin drift within the limits of the county, but the loess on the hills in the northeastern part of the county is quite sandy. Near the boundary between Lee and Jefferson townships, the northeastern townships, various outcrops of Des Moines strata protrude from the hillsides, while in the western part of Jefferson township they are concealed by the drift.

The loess lies unconformably on the Kansan drift, and the drift unconformably on the Carboniferous strata.

The relation of the drift to the underlying strata reveals the general plan of the preglacial drainage as contrasted with the present drainage.

* "Geology of Warren County," in Iowa Geological Survey, vol. V, p. 318.

The dotted line represents the boundary line between the surface outcrops of the Des Moines strata on the east and the Winterset strata on the west. The main points of difference

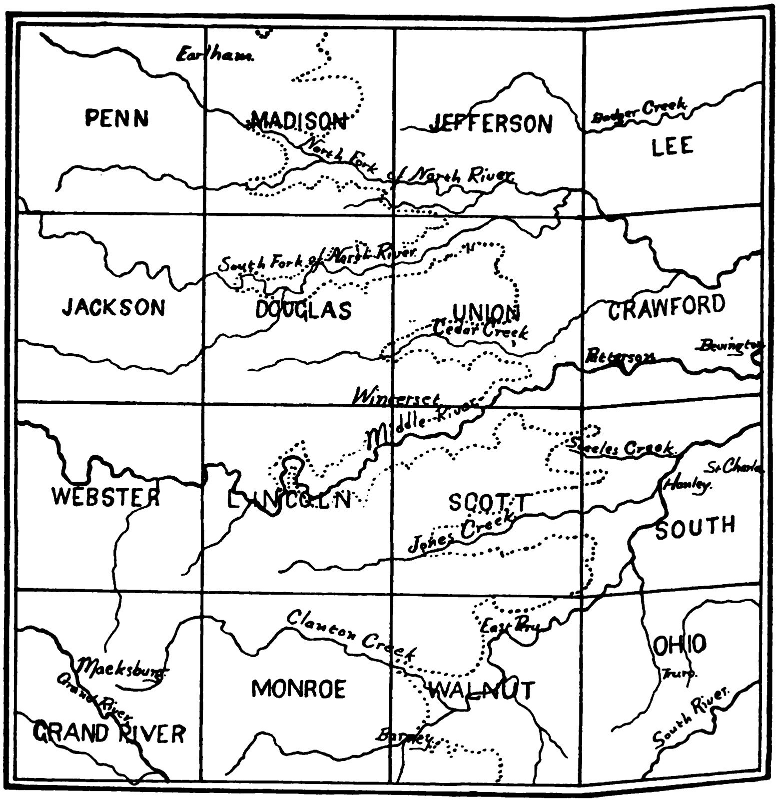

Fig. 1. Present drainage of Madison county.

are as follows: The drainage of Jefferson township was southeastward along the front of the Winterset limestone to North river. Because of the drift, Badger creek now flows northeastward over the drift across Jefferson township, then southeastward across the pre-Kansan divide, then eastward across Lee township. The stream seems to follow pre-Kansan ravines, but does not cut through the drift.

A preglacial valley extends southwestward from the western part of Lincoln township across the southeastern part of Webster township and thence across Grand River township. This old valley is now completely filled by drift, and the drainage, which was formerly turned toward Middle river, is now turned

southeastward into Grand river, a stream that is post-Kansan in Madison county. Middle river, west of Lincoln township, formerly uniting in section 21 of Lincoln township with the

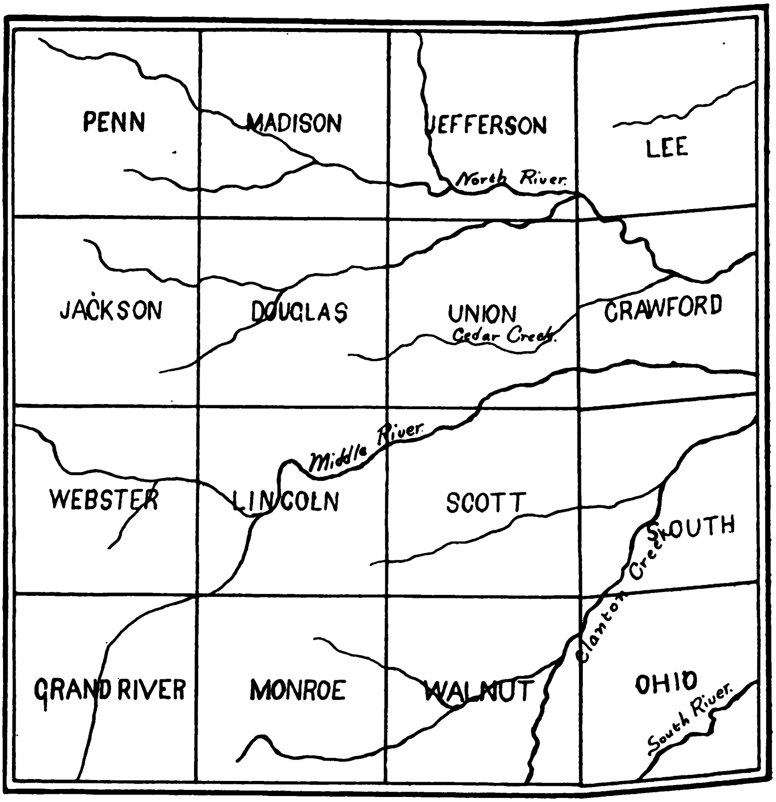

Fig. 2. The lines of preglacial drainage in Madison county.

stream from Grand River township, flowed in a large curve northward and then eastward, leaving in the bow thus formed that delightful and somewhat romantic "Devil's Backbone."

East of Barney the main part of Clanton creek seems to have flowed northward across section 35 of Walnut township.

The following streams are in preglacial valleys of their own: North river, Middle river, South river, Clanton creek, and the principal parts of Cedar creek, Jones creek and Steels branch; but the valleys are all much modified by the drift, and there is evidence of long-continued erosion during the time that was post-Kansan and preloessal. The smaller ravines forming the heads of the larger ravines are post-glacial.

The geest, the weathered coal measure surface of preglacial times, forms no important part of the soil. It is completely obscured by drift and loess, excepting where exposed by erosion.

The strata underlying the drift in the eastern part of the county belongs to the Des Moines stage of the coal measures. The strata underlying the drift in the western part of the county belongs to the Missourian stage of the coal measures. The dividing line between the surface outcrops of these stages may be traced as an irregular line across Madison township, the northeastern part of Jefferson, the central part of Douglas, Union and Lincoln townships, the eastern part of Scott and the central part of Walnut townships. (See figure 1.) The general surface of the limestone to the west of this line is higher than the surface of the shales east. This difference in elevation, together with the presence of preglacial valleys along the eastern margin of the Missouri limestone except in the divide just south of Patterson, make the limestone form an escarpment across the county.

East of the dividing line the strata are generally clayey or sandy shale, but there are outcrops of a layer of limestone from one and a half to two and a half feet thick, especially important in the neighborhood of Truro, hence here called the Truro limestone. It outcrops along South river at an altitude of seventy feet above the river bed, and on both sides of Clanton creek valley. It outcrops along the hillsides in Crawford township, and appears near the crests of divides between Lee and Jefferson townships. Its distance below the base of the Winterset limestone is eighty feet.

While in the Des Moines shales, unconformity is common, and in the sandy shales south of Patterson ripple-marks are to be found only forty feet below the Winterset limestone, there is no unconformity whatever between the base of the Winterset limestone and the uppermost Des Moines shales. This gives evidence that, just prior to the time when the Winterset limestone was deposited in the county, the shore line was farther inland (east or northeast) of the present limits of the limestone, and, with the gradation from sandy shales with ripple-marks, through clayey shales to Winterset limestone, sustains the conclusion previously advanced by Keyes that the Missourian limestone was formed in an advancing sea.

The succession of strata in the Winterset limestone is as follows, with uniform general characteristics throughout the county:

13 ft.	Limestone, very shaly above, lower part heavier but with varying thickness of marly partings. This forms the base of the Missourian limestone.
2 ft. 8 in.	Shale, clayey, gray above, black below.
4 in.	Limestone; dense, jointed.
9 in.	Shale, clayey, gray.
6 in.	Limestone, irregular, gray, fossiliferous.
2 ft. 6 in.	Shale, clayey, gray.
1 ft. 9 in.	Limestone, irregularly concretionary.
9 ft. 6 in.	Sandstone, shaly, gray.

In section 22 of Lincoln township the shales that are clayey in outcrops found in the northern part of Scott township, are calcareous shales, giving evidence clearly visible that the uppermost part of the Des Moines shales gradually changes into limestone toward the southwest. This necessary condition has been generally recognized concerning the Des Moines shales as a whole, but no transition now visible has to my knowledge been pointed out, unless it be in the deep well records of Montgomery county.

While there may be a marked difference in fauna between that of the Des Moines stage and that of the Missourian,* such distinctions as exist in the fossils seem satisfactorily referred to oscillation causing varying conditions of depth in the water with no very marked break. When the bottom of the sea was depressed, the deeper water fauna migrated into this deepening water. When the bottom was elevated, the deeper water fauna moved farther out to conditions more favorable, while their place was taken by a shallow water fauna. Of course if the Winterset limestone, and its shore equivalent, were laid down in an advancing sea, there must have been unconformity beneath the deposits somewhere, but not where the strata are still existing in Madison county. The changes in depth of water are accompanied by changes in the character of the strata. These

*University Geological Survey of Kansas, vol. I, p. 181.

changes, based on the succession of strata within the county, may be represented in the on following diagram:

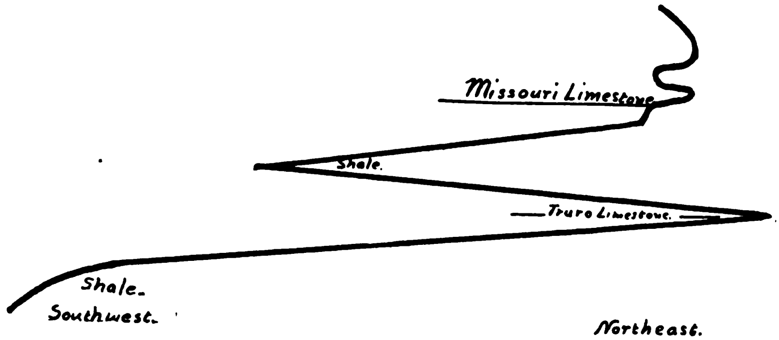

Fig. 3. Diagram representing the relative positions of the shore lines as indicated by the general character of the strata within Madison county.

NOTE.—A later comparison of outcrops proves that those shales in the upper Des Moines which are mentioned in this paper as calcareous, lie a few feet above those to the east with which they were compared; hence the local evidence mentioned that the upper part of the Des Moines shales becomes calcareous toward the west is wanting.—AUTHOR.

DRIFT SECTION AT OELWEIN, IOWA.

BY GRANT E. FINCH.

Just outside the limits of the growing town of Oelwein, Iowa, to the southeast, the Chicago Great Western Railroad company, in order to lessen a troublesome grade, have excavated a cut nearly a mile in length. At the end farthest from the town, where it passes diagonally through a ridge, it has a maximum thickness of thirty-two feet. This ridge has a northwest-southeast trend, and is one of the ordinary gentle swells characteristic of the drift of this region.

To pass along the front of so extensive a section, twice the depth of ordinary drift cuts, fresh and untarnished by sun and rain, is a pleasure to any one, whether geologist or not. The great variety of colors—strata black, brown, gray, blue, green, and several shades of yellow; the distribution of boulders like plums in a Christmas pudding; the intricate twistings and turnings of some layers and the unexpected, fantastic intrusion of others, all could not help but hold the eyes of both trained and untrained observers.

Though of great interest throughout its entire length, the section exposed where the cutting pierces the before-mentioned

ridge proved most interesting to me, and I shall therefore attempt its description somewhat in detail.

Beneath the eighteen inches or so of black soil at the surface, covering the top and slopes of the hill, is a yellow clay with a liberal admixture of sand, gravel, pebbles and boulders. Many of the boulders show striated and polished surfaces. Numerous small, angular fragments of limestone are everywhere present. In one of these was a number of specimens of *Nucula levata*, a lamellibranch which is found in the Maquoketa shales. There are great variations in the composition of this bed, but they occur in the form of irregular, curling drifts rather than of definite strata. This lack of any definite plan of structure combines with the great variety of materials found to give the yellow clay the heterogeneous look of a dumping ground.

At an average depth of about eight feet below the surface the yellow clay shades almost imperceptibly into a blue, which is so tenacious and compact as to require the use of the pick instead of the shovel in digging it. It offers an effectual barrier to water, which readily penetrates the loose, sandy clay above. It is everywhere broken up into polyhedral, usually cubical, fragments, whose angles project conspicuously in the face of the exposed section. This tough blue clay fills a trough under it, and rises in a broad curve above, determining the form of the hill; hence, it varies much in thickness. Below the highest point of the hill it is fully eighteen feet thick; three hundred feet either side, about one-fourth as much. Its structure is fairly uniform throughout. Boulders are very few and much decayed. Limestone fragments are found, as in the bed of yellow clay above, but there are also small fragments of wood and peat sparsely scattered through the whole bed, several fragments of both being found within eight feet of the surface of the ridge.

Next below this lenticular bed of clay is a bed of grayish-blue clay which has a nearly uniform thickness of about four feet. This bed curves downward at the center, its lowest point being about under the crest of the ridge. While the face of the section was fresh and unaffected by exposure, no distinction was noticed between this and the lenticular layer of clay above, but after repeated visits, the last one after the clay had been washed by the heavy rains and repeatedly frozen by night and thawed by day, a dim yet definite line of demarkation was visible.

Under the action of weathering this lower blue clay became distinguishable too, by reason of its smoothness of surface, from the upper blue clay, the face of which it has been already stated is covered with rough right-angled projections.

This difference would seem to be caused by a greater proportion of sand in the lower clay, which may be seen by close inspection to be the case.

Thus, while weathering dims the attractive colors, while it mutilates and must soon destroy the exposure, its immediate effect is to reveal stratification and texture that in the fresh surface of the glacial section are sometimes concealed.

This lower blue clay also shows a liberal number of angular fragments of limestone, one being observed which was a foot square and three inches thick. The entire bed, too, is found to be strongly impregnated with lime.

Fragments of wood are abundant throughout this four feet of sandy clay with its mixture of lime. Though the wood is fairly uniform in distribution in the different parts of the stratum, there seems to be no observable system in its distribution, no definite forest bed corresponding to the numerous instances given by McGee. This would seem to indicate that these woody fragments had been borne in from elsewhere rather than overwhelmed *in situ*.

The woody remains consist of stumps, trunks, branches and twigs. Such short roots are found only as remain attached to the stumps. The tree trunks are most frequently in a horizontal position, and in that case are flattened out of the cylindrical, thus showing the effects of pressure from above, since the vertical diameter is the shorter one. The maximum thickness of the trunks observed was eight inches, in a much decayed specimen. The length was uncertain. Preservation of the bark was observed in very few instances.

Nearly all the specimens found appear to belong to the same species. Its lines of growth are very close together, an indication that it grew slowly. It is apparently some soft wood.

All of the wood when found was saturated with water, which dried out very slowly on exposure to the air.

Though wood is found in both strata of the blue clay, fifty fragments may be found in the lower to one in the upper. Besides, the fragments in the lower bed are by far the larger.

It seems worthy of notice that the lower blue clay was deposited so evenly over the undulating sides as well as the

bottom of an irregular, basin-like depression. Taking this into account, and the difference in the occurrence of the wood of the two strata and their definite line of separation, one wonders whether the relation of the lenticular layer of clay may not be closer to the yellow clay above than to the blue below. The gradual blending of the upper into the middle stratum has been noticed, and the fact that wood occurs even in the transition between the two beds leads one to question whether it might not have been found up through the yellow clay were not that bed so loose of texture.

Next below the four feet of blue clay occurs a peaty bed that shows the same saucer-shaped depression as the clay above. On its upper surface, separating it from the clay, is a sheet of incoherent white sand which is fairly pure and shows irregular lines of sedimentation. Its thickness varies from nothing to six inches but it is fairly constant over most of the surface of the peat. The peaty formation has at the center a thickness of four feet, but it thins out and disappears within 300 feet in either direction. Its brown color makes it the best defined bed of the exposure, yet it is in structure far from uniform. The planes of stratification are frequently irregular, rising through the bed to the eastward. Such parts are clearly the results of sedimentation. Other layers are pure peat in regular and extensive sheets composed of closely compressed laminæ of moss as plain as if it was fresh from the botanist's press. These are certainly *in situ.*

Other vegetal remains than moss are wanting. Repeated and careful search discovered but one fragment of wood which was found in a sandy loam that underlies a small part of the peat. No roots are found except small ones, apparently those of the moss. Below the peat is a greenish colored clay, the lowest formation found. At the middle of the section it is invisible because below the bed of the cut, 300 feet either way it rises to a height of six or eight feet. It is a compact clay containing a considerable amount of sand and quartz, and other crystalline pebbles, but no limestone fragments, neither does this formation, nor the peat, show any impregnation with lime.

In the depression in this green glacial clay must have existed the swamp where the peat bogs formed during a great pause in the Ice Age. Upon this peat marsh came a flood of clay and sand bearing in its embrace the forest debris and limestone fragments. Next came a huge windrow of drift building a hill

over the ancient marsh; lastly, the mantle of yellow clay on which another soil has formed and now bears another growth of vegetation.

Thanks are due to Professor Calvin for kind encouragement and for the photographs of the section; to Professor Sardeson, of Minneapolis, for helpful suggestions, and to Engineer Wilkins, of the Chicago Great Western railroad, for use of the profile map.

EXPLANATION OF PLATE I.

Section of Pleistocene deposits as shown in the railway cut at Oelwein.

1. Thin layer of Iowan drift. Materials unoxidized, and boulders fresh and sound.
2. Kansan drift, oxidized and leached near the top. Many of the boulders in an advanced stage of decay. Grades downward into unoxidized blue till.
3. Sand boulders in Kansan drift. Upper ends are included in oxidized portion of this drift sheet; lower ends extend down into unoxidized portion.
4. Lower phase of Kansan drift which here shows physical characteristics resembling Number 7.
5. Thin layer of stratified sand, of Aftonian age, overlying peat.
6. Peat bed of Aftonian age.
7. Sub-Aftonian drift.

EVIDENCE OF A SUB-AFTONIAN TILL SHEET IN NORTHEASTERN IOWA.

BY S. W. BEYER.

Until very recently, geologists working in Iowa have been content to refer the various boulder clays represented in the state to two till sheets, a so called "upper" and "lower," separated in many places by the "forest beds" of McGee, or in other localities by gravels, often in conjunction with a vegetal horizon, the Aftonian of Chamberlin.

Early in the present year it was suspected by the assistant state geologist of Iowa that the lower till in central Iowa was not the equivalent of the lower drift sheet at Afton Junction. Later in the season Mr. Bain, in company with Prof. T. C. Chamberlin of the University of Chicago, revisited the Afton section, and what was at first a suspicion rapidly became a conviction. It was clear that the then recognized lower till of central and northeastern Iowa, extending southward into Kansas


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and currently known as the Kansan, must be correlated with the upper till at Afton Juncton. The Aftonian gravels were demonstrated to lie below the Kansan instead of above it, and the lower boulder clay at their type locality must be rechristened. Professor Chamberlin,* in an editorial on the series of glacial deposits in the Mississippi valley, designates the lower till at Afton by the term sub-Aftonian and suggests its probable equivalency with the Albertan of Dawson.

This fortunate discovery and happy recognition of a sub-Aftonian drift sheet in south central Iowa naturally suggested its probable presence in other portions of the state.

During the present autumn one and perhaps two sections in northeastern Iowa have been brought to light which afford additional evidence of a pre-Kansan ice sheet.

Oelwein Section.—The cut on the Chicago Great Western railway, east of the town of Oelwein, in southern Fayette county, exhibits the following series of glacial deposits:

5.	Boulder clay, rather dull-yellow in color; the upper portion is modified into a thin soil layer. Large boulders, mainly of the granitic type, are present, often resting on or partially imbedded in the deposits lower in the series. (Iowan)	0–10 feet.
4.	Sand and gravel—not a continuous deposit; often shows water action expressed in parallel stratification lines and false bedding. The gravels are usually highly oxidized and fine textured. (Buchanan)	0–2 feet.
3.	Till, usually bright-yellow above, graduating into a gray-blue when dry or a dull-blue when wet, below. This deposit is massive and exhibits a tendency to joint when exposed. Decayed granitic boulders are common. (Kansan)	3–20 feet.
2.	(*a*) Sand, fine-white, well water-worn; often with a slight admixture of silt and clay. (Aftonian)	0–6 inches.
	(*b*) Vegetal layer and soil, from two to four inches of almost pure carbonaceous matter, with one to three feet highly charged with humus. The peaty layer often affords specimens of moss (Hypnum) perfectly preserved. (Aftonian)	0–4 feet.
1.	Till, greenish-blue when wet or gray-blue with a greenish cast when dry. Greenstones and vein quartz pebbles predominate. (Sub-Aftonian or Albertan.) Exposed	10 feet.

The Oelwein hill trends northwest and southeast and is bilobed. The divisions will be referred to in the present paper as east and west lobes.

* Journal of Geology, vol. IV, No. 7, p. 873 *et seq.*, 1896.

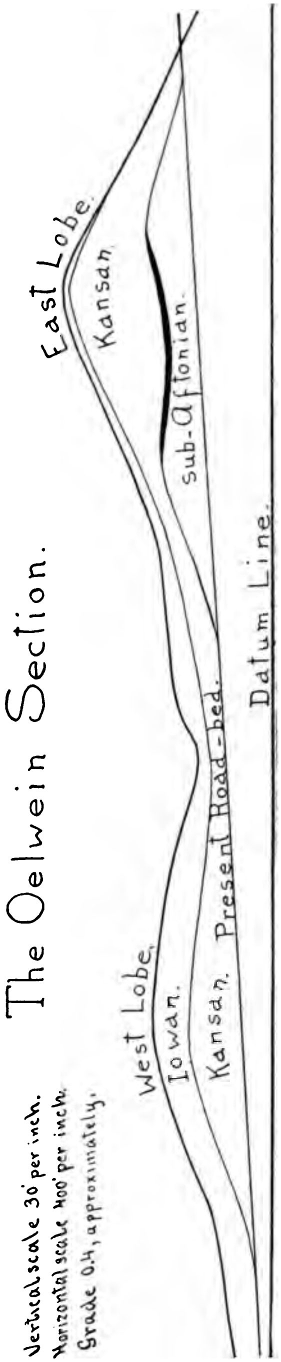

Fig. 4.

The Iowan reaches its maximum development near the summit of the west lobe, where it attains a thickness of some ten feet. The deposit thins eastward. At the crest of the east lobe little more than a foot of Iowan till is present, while at the extreme eastern limit of the cut Iowan boulders are partially imbedded in the Kansan. The till varies from a pale yellow to a moderately bright yellow color, and is not thoroughly leached nor oxidized. The Iowan shows a tendency to crumble on exposure, which is in striking contrast to the older drift sheets.

The line of separation between the Iowan and Kansan is not as well marked, in all cases, as could be desired but in most instances can be traced with some degree of confidence. In the west lobe a layer of sand sharply divides the two sheets for a distance of 100 feet, but when followed in either direction becomes much disarranged by the latter and in some places entirely loses its identity.

The Kansan is the predominant sheet in the cut and the topographic features of the region are faithfully depicted by the stiff boulder clay of this deposit. Its maximum exposure is in the east lobe, where it exhibits a thickness of twenty feet. The upper portion is oxidized to a bright yellow, sometimes brownish-yellow, often closely resembling the Iowan in color. The most distinctive feature in its separation from the latter are the character of the included boulders and the greater tenacity of the Kansan till. The Iowan pebbles and boulders are prevailingly of the granite type and

well preserved, while in the Kansan, greenstones are common and many of the granites are in an advanced state of decay. A granitic boulder more than a foot in diameter was noted which had been cleaved by the steam shovel without being loosened from its matrix. Sand boulders, lenses and wedges anomalously distributed through the oxidized portion and often extending into the upper portion of the blue till are common features. The wedges usually maintain a more or less vertical position with their apices pointing downward. The filling material in all cases very closely resembles the sand layers between the Iowan and Kansan. Oftentimes the position of the various sand forms is such as to suggest their common origin with the Buchanan. In many instances stratification lines are common. In the trough of the hill the lower portion of the Kansan contains lime concretions similar to the loess-kindchen and püppchen in great numbers. The lower three or four feet of the blue till contains wood fragments in considerable abundance in a state of almost perfect preservation. The physical properties of this portion of the Kansan are very similar to the sub-Aftonian.

The dividing line between the Kansan and sub-Aftonian is more sharply marked than between the upper two drift sheets. In the major portion of the section the sand layer and the peat bed are continuous, demonstrating the extreme gentleness of the advance of the Kansan ice. It seems remarkable that perhaps the greatest ice sheet that ever appeared in the Mississppi valley could override a peat-bog with no perceptible disarrangement of materials. The pertinence of Prof. T. C. Chamberlin's remark is apparent "that a glacier builds its own causeway." The surface of the sub-Aftonian is much more even than that of the Kansan; in fact it is not unlike that ascribed to our more modern peat-bogs. In certain places the upper part of the sub-Aftonian has been shifted and spheroidal masses of the peaty soil appear at the junction line imbedded in a Kansan matrix.

The drift sheet below the Kansan is represented by a massive gray-blue till with a marked greenish tone when unoxidized. The upper portion contains much humus and gives off a characteristic marsh-like odor when wet. The distinctive characters which serve to distinguish this boulder clay from the preceding are its color, the predominance of greenstone, and vein quartz pebbles and a less tendency to joint on

exposure. Granitic pebbles and boulders are, almost if not entirely, wanting. The pebbles in this as in the Kansan often exhibit polished, striated and facetted surfaces. The sub-Aftonian shows oxidation only where the superficial deposits are thin and the indications are that such oxidation took place after the deposition of the Kansan. At the extreme east end of the cut, beyond the peat-bed, there is an apparent exception to this rule. Blue till boulders of the Kansan are imbedded in an oxidized matrix of the basal drift sheet.

Albion Section.—Another section has come to the writer's notice during the past year which bears additional testimony to a drift sheet older than the Kansan. At the Albion mills on the Iowa river about ten miles northwest of Marshalltown, the following series of deposits may be observed:

6.	Loess, stratified sands below	20 feet.
5.	Till, yellow in some places apparently wanting and often represented by characteristic boulders, only. (Iowan)	0–1 foot
4.	Gravel, some boulders four or five inches in diameter; granitic members often much decayed; limestone pebbles are common and boulders of Kansan till decorated with pebbles were noted. (Buchanan)	2 feet.
3.	Till, the upper portion highly oxidized to a deep reddish-brown, unoxidized portion a gray-blue, exhibiting a jointed structure. (Kansan)	4 feet.
2.	Sands and gravels, stratified and coarser below; oxidized in streaks, and bands approximately parallel to bedding planes; certain bands contain a considerable percentage of silt and clay. (Aftonian)	10 feet.
1.	Till, blue. (Sub-Aftonian)	10 feet.

The Kansan at this point is more highly oxidized than at Oelwein, while the gravels between the Iowan and Kansan are very sharply defined.

The Aftonian does not present the iron-stained appearance usual to such deposits. Many of the pebbles and boulders are, however, in an advanced stage of decay.

EXPLANATION OF PLATES.

Plate II. The Oelwein Section.

1. Sub-Aftonian.
2. Aftonian.
3. Kansan, composed of an upper oxidized and a lower unoxidized portion.
5. Iowan.

Plate III. The Albion Section.

2. Stratified sands and gravels of the Aftonian.
3. Kansan till oxidized in part.
4. Buchanan, consisting of coarse gravel.
6. Loess, with stratified sands and silts below.

PLATE II.


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A PRE-KANSAN PEAT BED.

BY T. H. MACBRIDE.

In making an excavation through a low ridge just east of Oelwein, in Fayette county, the workmen of the Chicago Great Western railway have recently brought to light some very interesting superficial or quaternary deposits. As to the nature, age and significance of these deposits taken as a whole, our geologists are no doubt ready to give early and accurate account. It is for me in this brief paper to discuss, from the standpoint of the botanist, a single member of the series of strata thus fortunately brought to light.

By way of description it is sufficient to say that the railway cutting mentioned displays on the face of an almost vertical wall a succession of well-defined deposits in which have been recognized the two principal drift sheets with which Iowa is known to be more or less covered, the Iowan and the Kansan, and at least one more, prior to the Kansan and, of course, underlying it. These drift sheets or deposits are separated from one another in the Oelwein exposure, as elsewhere, by thin carbonaceous strata, the evidence of the vegetation which at one time covered the surface of the older deposit. At Oelwein one of these carbonaceous division sheets, and that the lowermost, is of remarkable prominence and thickness, and to this particular layer your attention is now invited.

Those who have had experience in such studies, and who have attempted to trace the limits of superficial deposits, know that contact lines are often exceedingly obscure; the strata are recognized by more or less abrupt change of color, or, at best, by simply a darkened trace; but here we have a stratum in some places nearly a foot in thickness, so purely organic as to form almost a brown coal, an unusually pure quality of peat, and so striking in appearance as to have won the attention of even the men of pick and shovel. The deposit is actually more dense than the clay or drift layers above and below, so that weathering brings it out as a distinct ledge to-day on the face

of the exposure. The stratum from the point of best exposure dips to the west, and, so far as I could observe, can be followed in that direction no more than twenty or thirty rods when it dips below the present level of the excavation. Eastwardly it thins out, and at length becomes only a trace, obscure, or vanishes entirely. For the greater part of the entire distance the structure and composition of the bed varies from rod to rod, but everywhere where the exposure is thickest the purity of the seam is greatest below. Indeed, in the most favorable case examined the purity of vegetable accumulation near the bottom of the formation is remarkable in the extreme, there being no admixture, so far as can be discovered, of any other substance whatsoever.

Upwards the materials are less pure, the amount of inorganic matter increasing until the seam blends above with the overlying blue clay or drift. It is a little surprising to find the lowest, that is, the oldest part of the bed, exhibiting organic objects in most perfect condition. The bottom of the seam is a compact mass of moss, compacted and pressed together no doubt, but absolutely untouched by putrefaction or decay, perfect in every leaf and fibre as any herbarium specimen in the world. Specimens you may examine show this perfectly. You may see the stem, the attachment of the leaves, the innovations, the form of each leaf, nay, the very areolation of leaf apex and base, quite as absolutely defined as in the case of any freshest specimen one may bring in now from any living turf or forest bed. For this reason we are able with much confidence to identify the species concerned although, so far, we have seen no smallest sign of capsule or fruit. So far, also, all the material seems to represent but a single species, a *Hypnum*, probably *Hypnum fluitans* Linn., a common moss which creeps out from shore or clings to floating objects, itself immersed or semi-floating in ponds, marshes or peat-bogs around the whole northern world.

Above the compacted moss which altogether makes up an inch or two of solid matter, lies a still more solid mass of vegetable detritus several inches thick. In this case the vegetation, whatever it was, appears to have undergone pretty thorough decomposition and disintegration before it was compacted. The microscope reveals simply cells and fragments of cells with considerable admixture of sharp, white sand, but nothing identifiable. This pulpy layer blends rather abruptly above

with a crude admixture of sand, mud and fragmentary vegetable detritus which, as said, becomes at length indistinguishable from the overlying drift.

In the very lowest portion of the (upper) drift, and often resting directly on the peat seam proper, are quantities of half-decomposed wood, not rotten wood at all, rather wood which has lost its lignin and of which only the cellulose basis remains, but showing all the original structure elements and features with perfection absolute. The wood seems identical with that of *Larix americana* Mx.

The facts before us would seem to warrant the following conclusions in reference to the state of affairs or conditions under which the peat bed was laid down: The *Hypnum fluitans*, free from all foreign matter of every kind, bespeaks a wide, clear, open marsh or peat-bog to which anything like muddy drainage from the surrounding regions never came. Here for a long period, probably centuries, the moss must have flourished undisturbed, but was at length completely submerged and drowned, probably by the closing of the drainage outlets. In the deeper water that succeeded flourished a different flora, probably a surface aquatic flora such as the *Lemnas*, filamentous algæ, *Anacharis*, possibly, whose dying fronds and filaments settled through other centuries to form at last the second layer of our peat bed seam. Over this, as has been stated, lies a mixture of organic and inorganic matter. Whether this was deposited *in situ* by another change in the depth of the water and local surface conditions or whether this represents the lowest part of the drift sheet as it came is difficult to say. In this particular layer there are evidences not a few of the presence of higher plants, monocotyledons chiefly. These may have been pushed in from other shallower parts of the same marsh. However this may be, the final catastrophe is not a matter of doubt. The whole region was slowly frozen up and at length whelmed by an icy deluge of frozen mud, fragments of swamp-loving trees wrenched and broken as they came, sand boulders, detritus of all the surrounding surface soils, whatever their variety, their flora or formation. Once this process complete, our peat bed remained hermetically sealed, unaffected, doubtless, by subsequent surface changes of any sort until stirred by the plowshare of the railway engineer. Considering the assumed great age of the deposit the state of preservation in which the plant remains occur is truly noteworthy. But then

we recall the notorious fact that peat-bogs and marshes, whether by the abundance of humic acid or from other causes, are pronouncedly aseptic. If moss, developed under such conditions, was finally buried at a low temperature and sealed up, its preservation is explained. But again, the wood fragments referred to are saturated with a solution of ferrous sulphate. The occurrence of this salt in this condition is a problem to which the attention of the chemist, rather than of the botanist, may be invited.

In closing, one other fact may be mentioned. Some years since well diggers of Washington county, in the town of Washington, brought up from great depth, some hundreds of feet, a perfectly preserved and uninjured cone. This I identified at the time as the fruit of *Larix americana*. If our determinations are therefore to be trusted, the Oelwein peat bed and the Washington cone represent the same horizon. As the only drift in Washington county is Kansan, the position of the Oelwein peat as pre-Kansan is to this extent rendered more certain.

SUMMARY OF DISCUSSION*.

BY PROF. S. CALVIN.

The discussion following the preceding papers on the Oelwein section was participated in by Calvin, Fink, Bain, Shimek, Beyer, Finch and others. The facts developed during the discussion may be summarized as follows:

A few years ago geologists were content to look upon the glacial period as a unit, and the drift mantle of Iowa was regarded as the effect of a single invasion and retreat of glacial ice. Some time ago, however, McGee demonstrated that in northeastern Iowa there are two distinct drift sheets separated by a soil horizon and forest bed which represent an interglacial period of considerable length. The two sheets of drift were then named respectively the lower and the upper till. Later two distinct drift sheets were recognized in Union county, near Afton Junction. They are separated by a soil bed and by

*A motion that Professor Calvin be requested to summarize this discussion was carried unanimously.

extensive deposits of water-laid gravels. It was at once assumed that the two drift sheets at Afton Junction were the upper and lower till of McGee. Within the past year or so Mr. Bain, of the Iowa Survey, studied the Afton deposits and became convinced that the till above the gravels and soil bed was equivalent to McGee's lower till, that the upper till was not present in that part of Iowa, and that the lower bed at Afton is distinct from any of the drift sheets recognized in northeastern Iowa. The locality was afterward visited in company with Professor Chamberlain and others and Bain's conclusions were fully confirmed. Here is a drift sheet older than McGee's lower till. In the meantime a lobe of drift, crossing the northern boundary of the state with a width reaching from Worth to Dickinson counties and narrowing toward its apex at Des Moines, was recognized as younger than the upper till of McGee. This youngest drift has been named Wisconsin by Chamberlin, McGee's upper till Chamberlin calls Iowan, and the lower till Kansan. The drift beneath the Aftonian soil and gravels is so far unnamed, but it is provisionally called sub-Aftonian. Mr. Leverett has recently shown that a bed of till occupying a small area in southeastern Iowa was deposited by glaciers coming from the northeast through Illinois. These glaciers spread a characteristic sheet of till over a large part of the state last named, and this drift sheet, which is younger than the Kansan and older than the Iowan, is called the Illinois.

There is therefore in Iowa a record of five ice invasions separated from each other by interglacial periods of considerable duration. The drift sheets corresponding to the several ice invasions are named in the order of age: 1, sub-Aftonian; 2, Kansan; 3, Illinois; 4, Iowan; 5, Wisconsin. The interglacial deposits between the first and second are called Aftonian. Respecting the length of the interglacial periods it may be shown that many of them were many times longer than the period that has elapsed since the retreat of the Wisconsin ice. The Oelwein cut to which reference is made in the papers under discussion is particularly interesting for the reason that it shows three of these drift sheets, the sub-Aftonian, Kansan and Iowan, in their normal relations. The first and second are separated by the peat bed which represents the Aftonian interglacial period. The second and third are separated by a zone of oxidation. The Iowan drift at the top of the cut is thin, but it contains boulders fresh as when they left the parent ledge.

The Kansan drift is thicker. It is deeply oxidized at the surface, and its granite boulders are so far decayed that the steam shovel has cut through individuals a foot or more in diameter without encountering as much resistance as is offered by the surrounding clay. The sub-Aftonian contains small pebbles of very hard crystalline rocks, many of the pebbles being of vein quartz, but there are few granites. Concerning the climate of the Aftonian interglacial period the wood and peat would indicate conditions similar to those that may exist in northern Maine.

Iowa is now classic ground for the study of Pleistocene deposits, and geologists the world over, if they would study these deposits to best advantage, must come to Iowa to do it.

ADDITIONAL OBSERVATIONS ON SURFACE DEPOSITS IN IOWA.

BY B. SHIMEK.

During the past summer the author made a series of observations, at the request of Prof. S. Calvin, upon the surface deposits of the northern part of the state, the results of which may be worthy of record.

Borings were made with a two and one-half inch auger attached to gas pipe, and in addition to this cuts along railways and wagon roads and exposures along creek and lake shores were examined. The chief observations were made at the following points:

a. At Clear Lake, in Cerro Gordo county, three borings were made in the timbered ridge east of the lake, as follows: One within five rods of the lake shore and two on the topmost part of the hill to the east.

b. At Forest City the following work was done:

1. Eleven borings were made due east from Forest City on the timbered ridge which extends north and south, parallel with Lime creek and just east of it, beginning at the top of the ridge north of the road, and thence at irregular intervals for 450 yards to the south. Nine of these borings were made at or near the summit of the ridge and two, one on each side, were made near the foot.

2. Two borings were made on a little plateau about one-half mile east of Lime creek, and notes on a well near by were taken.

3. Two borings were made on the timbered ridge south of Forest City, and several cuts along the Minneapolis & St. Louis railroad and at the gravel pit two miles south were examined.

4. Two borings were made between Forest City and Lake Edwards (in Hancock county), one near the top of a hill on which a few bur oak shrubs had gained a foothold, and one on lower ground. Observations were also made in cuts along wagon roads west of Forest City.

5. Well diggers were consulted at Forest City.

c. At Spirit Lake, in Dickinson county, exposures along the lake shores and cuts along railways and wagon roads were studied.

d. Near Granite, in Lyon county, five borings were made at various altitudes, about one mile west of Granite and south of the railroad, and observations were made in the railroad cuts between Granite and the Big Sioux river.

The results were fairly uniform and are here briefly summarized.

The succession of strata in the great majority of cases was as follows:

1. A fine black surface soil, sometimes mingled with fine sand, varying in thickness from six inches to two feet.

2. A compact yellowish layer of clay resembling loess, but sometimes with grains of sand and very small pebbles intermingled, and devoid of fossils. This is sometimes quite absent, but again reaches a thickness of nearly two feet.

3. A layer of yellow boulder-clay, with numerous boulders, these often several inches in diameter, occasionally much larger.

4. The boulders interfered with the borings, but where deeper sections could be observed it was found that this layer varied from five to fifteen feet in thickness.*

Where borings were made in low or flat grounds it was found that strata 1 and 2 averaged a little greater in thickness, and stratum 1 was rather more frequently mingled with sand.

The borings at Clear Lake and east of Forest City were made in the timber. In all these stratum 1 was greater in thickness and was mostly made up of finer material.

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* Beneath this layer at Forest City occur pockets of sand, underneath which is a blue boulder-clay of great thickness, said by the well diggers at Forest City to vary from sixty to 100 feet in that vicinity.

The yellow boulder-clay—stratum number 3—has boulders scattered throughout its thickness, but, as a rule, on slopes and near the tops of hills these are much more abundant in the upper part, immediately under strata 1 and 2.

This is strikingly shown in some of the cuts and exposures at Forest City, Spirit Lake and Granite. It appears as though this stratum had at sometime been much thicker upon the hills, forming their barren surface immediately after the recession of the glacial sheet. By the action of winds and water the finer material at the surface was sifted out and carried away before the hills were covered with vegetation, the heavier boulders being but little disturbed, excepting as they were undermined. As a result the hills were cut down and the boulders were brought closer together at the surface. Their accumulation retarded the surface disturbances and the vegetation peculiar to barren grounds was enabled to gain a foothold. Finer material, brought hither by the winds,* was retained by this vegetation and a new surface soil was formed—the stratum number 2—of which a vegetation more abundant then took possession. This retained still finer material, mingling with it its own decomposed substance, and the present surface soil—stratum number 1—was gradually formed. It may here be noted that the finest part of the material from stratum number 3 seems to be in all respects like our loess.

The conditions which probably prevailed before the formation of strata 1 and 2 are still illustrated by comparatively barren prairie hills west of Forest City and in the vicinity of Granite, where stratum number 3, or mere indications of number 2, form the surface, whose vegetation, as incidentally noted in the following paper, is quite different from that of the more fertile surrounding prairie.

The occurrence of the scrub bur oak groves on some of these hills is interesting. The plants are chiefly shrubs, seldom more than five feet in height, and usually not closely crowded, and they seem to prosper best on the leeward side of the hills and in ravines.

This is strikingly shown near Granite. The observer may stand on one of the hills west of Granite, and looking to the

* Even such small pebbles as those which occur in stratum number 2 could be rolled a considerable distance by winds. The author saw, last spring, an accumulation of sand on a hill in the southern part of West Cedar Rapids which completely covered a fence fully five feet high. In the deposit were small pebbles, yet the wind had clearly formed the stratum full five feet in thickness since the fence had been built. When the workmen were removing a portion of the deposit for the purpose of opening a road it was observed (by the author) that the sand was quite regularly stratified, the numerous lines following the surface configuration.

south and southwest, and also to the west and northwest across the Big Sioux river into South Dakota, he may locate almost every one of the little ravines with which the slopes bordering the deeper ravines are scarred, by the dark lines of bur oaks. The number of these smaller ravines which are tributary to some larger one is often so great that a pinnate arrangement of these dark lines results. The shrubs in that vicinity are found generally on the northern and eastern slopes, where they are best protected from the prevailing strong southwesterly winds, and the surface soil on these slopes is much deeper and finer, and is also covered with a richer flora. On the other hand, many of the western and southern slopes are strewn with granite boulders, and a scant vegetation barely covers the surface, which almost lacks a finer soil—stratum number 3 forming the surface. These groves would probably have formed nuclei of greater forests had not man interfered, for, in the northern part of the state at least, the bur oak seems to be the pioneer among trees, being followed by the red oak, which now forms the greater part of our northern and northwestern upland groves.

The conclusion seems warranted that while soil largely determines the character of a flora, the converse is equally true that the flora will in time affect the character of the soil, and that the influence of vegetation upon superficial geological changes should not at least be disregarded.

The conclusions drawn from the observations here briefly recorded are the following:

1. The boulder-bearing stratum marked 3 formed the surface at one time throughout the region studied. Before vegetation had taken possession of it the finer material was sifted from the upper part of the stratum, concentrating the boulders.

2. Subsequestly a comparatively scant vegetation took possession, making possible the retention of a somewhat coarse soil,—stratum 2.

3. A richer vegetation then followed, enabling the retention of a finer soil,—stratum 1.

4. Forests, where occurring, followed next in order, being ushered in in the manner suggested by the present bur oak scrub-tracts.

5. The agency concerned chiefly in accumulating the finer surface soils was wind, the material being retained in place by vegetation.

6. The action was probably not simultaneous over the entire area, the fine material removed from the most barren parts being deposited in places already prepared for its retention.

THE FLORA OF THE SIOUX QUARTZITE IN IOWA.

BY B. SHIMEK.

The Sioux quartzite is exposed in this state
extreme northwestern corner of Lyon county.
greater exposures however are found in the adja
South Dakota.

The chief exposure on the Iowa side is locat
rods south of the state line and about one and t
miles east of the Big Sioux river.

It occupies a depression in the rolling prai
bordered by hills on the north, east and south
gradually to the Big Sioux bottoms to the wes
seen at and near the junction of two streamlet
from the east and the other from the south, the
resulting stream being westward.

At the time that the observations herein record
(August 4 and 6, 1896), these streamlets were alm
being only a few disconnected pools of water.

The greater portion of the exposure is horizontal, vertical ledges not exceeding six feet in thickness being found only along the streamlets for a few rods above their juncture.

The exposure is in part barely disguised by a scant surface soil upon which, and upon the bare rock, flourishes a flora in some respects unique, and strikingly different from that of the surrounding prairie, a fact already noted by Prof. J. C. Arthur, who in the "Contributions to the Flora of Iowa," No. VI.,* says: "The extreme northwestern corner (of Iowa) is geologically and botanically very unlike the rest of the state."

The list of plants herein given is undoubtedly far from complete, being the result of a rather hasty survey. It shows a flora which is sufficiently unique, however, to be of interest to the student of plant distribution.

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* Proc. Davenport Acad. Sci., vol. IV., p. 73.

The plants in the first list seemed to be restricted to the exposure and have not been collected anywhere else in the northwestern part of the state by the author, nor have they been reported from that section excepting from the immediate locality under consideration. They are:*

Talinum teretifolium Pursh. Abundant. Also reported from Woodbury county.

Hosackia purshiana Benth. Abundant. In fruit. Also reported from Henry and Woodbury counties.

Opuntia fragilis Nutt. Common. A few fruits were found.

Aphyllon ludovicianum Gray. Not common. Not heretofore reported from the state.

Isanthus cœruleus Mx. Not common. A stunted unbranched form. The species occurs in Henry, Muscatine and Johnson counties, in the eastern part of the state.

Polygonum tenue Mx. Common. Also reported from Linn and Muscatine counties.

Buchloe dactyloides Eng. Staminate plants were not rare.

Woodsia scopulina Eaton. Rather common. Found in crevices of the rock. This has not been reported from the state. The specimens, which were collected with fruit in all stages of development, are typical.

Selaginella rupestris Spring. Common. The species is also reported from Muscatine, Winneshiek and Benton counties.

Asterella hemisphœrica Beauv. Not common. Abundant in the eastern part of the state. With the exception of the liverwort *Asterella* all of the species in the list are distinctly dry and barren ground plants, and even the exception commonly occurs in places which are wet only during a short period each year. It will be noticed also that the species belong largely to the flora of the dry western and northwestern plains.

The second list includes plants which occur on this exposure, but are also found upon dry, sandy, or gravelly hillsides on the prairies throughout the northwestern part of the state, and also in isolated localities in other parts of the state upon sandy, barren tracts. These also belong to the western flora. They are:

Astragalus lotiflorus Hook. Not common. Found also on the barren hills near Granite. Heretofore reported only from Fremont county.

*The nomenclature here employed, excepting that of the lichens, is, like that of most of the Iowa lists heretofore published, that of Gray's Manual. Without regard to the merits of the nomenclature controversy, this will make the notes more convenient for comparisons.

Liatris punctata Hook. Not rare.

Chrysopsis villosa Nutt. Rather common. Not reported from Iowa.

Aster oblongifolius Nutt. Not rare.

Aster ptarmicoides T. and G. Not common.

Artemisia canadensis Mx. Not common.

Artemisia frigida Willd. Not common. Not reported from any other part of the state.

Lygodesmia juncea Don. Not common.

Cuscuta arvensis Beyr. Common, chiefly on the two species of *Artemisia* mentioned.

Pentstemon gracilis Nutt. In fruit. Not common. This is the first report of its occurrence in the state.

Pentstemon grandiflorus Nutt. Rare on the exposure, but very common on the barren hills west of Granite.

Verbena angustifolia Mx. Not common.

Plantago patagonica Jacq., var. *gnaphaloides* Gray. Common. Reported from several counties in the western and southwestern part of the state.

Oxybaphus hirsutus Sweet. Not common.

Salsola kali L., var. *tragus* (L.) Moq. A dwarf form not exceeding eight inches in height, with mostly simple stems, was quite common.

Bouteloua oligostachya Torr. Common.

Bouteloua hirsuta Lag. Not rare. Both of these species are quite common near Granite, and also near Rock Rapids, in Lyon county.

Carex stenophylla Wahl.* Not uncommon. A rare species, heretofore found in this state only in Emmet county.

Placodium vitellinum (Ehrh.) Naeg. and Hepp.† Not uncommon.

Placodium vitellinum var. *aurellum* Ach. Rather rare.

Placodium elegans (Link) D. C. Rare.

Placodium cerinum (Hedw.) Naeg. and Hepp. (?) Not common.

Lecanora cinerea (L.) Sommerf. Not common.

Lecanora rubina (Vill.) Ach. Quite common.

Lecanora muralis (Schreb.) Schær., var. *saxicola* Schær. Quite common.

Rinodina oreina (Ach.) Mass. Very common.

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* The species of Carex, mentioned in this paper, were partly identified or verified by Prof. R. I. Cratty.

† The lichens were identified or verified by Prof. Bruce Fink.

Parmelia conspersa (Ehrh.) Ach. The most common lichen on the exposure, covering large areas of rock.

Physia cæsia (Hoffm.) Myl. Not common.

Omphalaria ————. An undescribed species found in Iowa, Minnesota and Nebraska. Not common.

Pertusaria ———— sp. (?) Not common.

Endocarpon miniatum (L.) Schær. Rare. Probably a variety.

The lichen flora of the exposure, very conspicuous by its abundance and variety, is an exceedingly interesting one. The rock in many places is fairly covered with these persistent forms, and the species are, for the most part, identical with those which occur on surface granite boulders in the northern or northeastern part of the state.

In addition to the species given in the preceding list, there are several which may be found almost anywhere on the prairies, and which readily adapt themselves to new surroundings, yet are properly dry ground species. They are:

Delphinium azureum Mx. Not common.

Psoralea argophylla Pursh. Not rare.

Psoralea esculenta Pursh. Rather rare.

Castilleia sessiliflora Pursh. Rare.

Hedeoma pulegioides Pers. Very common.

Juncus tenuis Willd. Common.

Carex cephalophora Muhl. Not common.

Carex straminea Willd., var. *brevior Dewey*. Quite common.

Carex straminea Willd., var. Not common.

Andropogon scoparius Mx.* Common.

Stipa spartea Trin. Common.

Muhlenbergia glomerata Trin. Not common.

Sporobolus cuspidatus Torr. Common.

Calamagrostis canadensis Beauv. Common.

Calamagrostis longifolia Hook. Common.

This report would be incomplete without a list of the species which were found along the edges of the pools left by the streamlets. They do not properly belong to the flora of the rock-exposure, but their presence is of interest, especially as some of them were observed nowhere else in Lyon county. They are:

Rotala ramosior Koehne. Not common. Known heretofore only from Benton and Henry counties.

*For the identification of some of these grasses thanks are due to Prof. L. H. Pammel.

Ammannia coccinea Rottb. Not common. Reported only from Story county.

Veronica anagallis L. Not common.

Juncus nodosus L., var. *megacephalus* Torr. Not rare.

Beckmannia erucæformis Host., var. *uniflora* Scrib. Quite common near two of the pools, but not found by the author at any other point. It is also reported from Story (introduced) and Plymouth counties.

As has been noted, the plants which constitute this flora are for the most part inhabitants of dry and more or less barren regions. The flora may be duplicated in part in several barren isolated spots in other portions of the state. One of these is found in Muscatine county, and many of its interesting forms have already been reported by Mr. Fred Reppert; another is in Dubuque county; and still others are mentioned by Prof. L. H. Pammel.*

It is probably the remnant of a flora which once covered the greater part of the north half of the state. It is closer in its relation to the western than to the eastern flora, and its evolution probably took place to the west and southwest beyond the limits of the glacial sheet.

The recession of the glaciers left a barren surface, for the most part covered with sand and boulders, and seamed and scarred by the vast sea of ice. The depressions were occupied by water, and upon the bleak hills this flora slowly established itself. But its own presence gradually caused an accumulation of finer surface soil, and other plants, more vigorous and rapid growers, took possession of the now fertile spots. The fertile area thus increased until only a remnant of the original flora was left in the few spots which presented conditions most nearly like those which prevailed soon after the disappearance of the ice sheet.

The distribution of the lichen flora probably differed from that of the higher plants. The wonderful vitality of the lichens, especially as illustrated by their habits far to the north, admits of the belief that they were able to exist even through the glacial period. It is probable that the ledges of the Sioux quartzite, then much more prominent, were covered with lichens even before the glacial epoch, and that the same force which ground out the boulders from the solid rock carried fragments of lichens out over the state eastward and southward. It is

*Proc. Iowa Acad. Sci., vol. III, p. 106.

probable that the glaciers advanced and receded with the changes of seasons, and with each recession of the ice the lichens were given a new lease of life. Thus while the higher plants from the east and the west met on the barren prairies of Iowa, those from the west at first predominating, and while their advance was probably respectively from the southeast and southwest, the lichens of the rocky ledges and boulders came to us from the north and represent the oldest flora in the state.

NOTES ON AQUATIC PLANTS FROM NORTHERN IOWA.

BY B. SHIMEK.

The aquatic flora of northern and northwestern Iowa is of great interest, and it deserves especial attention because the occupancy of that part of the state by agricultural man is rapidly transforming the "Thousand Lake Region of Iowa," as the early settlers called it, into thousands of pastures, flax fields and wheat fields.

The lakes and ponds are being drained either artificially or by the changes in surface conditions, and while it is probable that the aquatic flora will persist in the larger lakes for a long time, it will certainly be restricted; it is, in fact, already restricted, and if these large lakes change as rapidly as Clear lake, Spirit lake and Lake Okoboji (to say nothing of smaller ones) have in the past few years, Iowa will soon know no lakes. It is important, therefore, that the history of the aquatic plants of the northern part of the state be as complete as possible, and that specimens of these plants be preserved for future reference.

Various scattered notes on this flora have been published, but thus far only one paper specially devoted to it has appeared. Early in the year Mr. R. I. Cratty published* an admirable paper on the aquatic flowering plants of Iowa, and these notes are practically merely supplementary to that paper. A part of the field work at Spirit lake and Lake Okoboji, the results of which are here given, was made in company with Mr. Cratty, and his experience and enthusiasm added much to the interest and the value of the work.

*Bulletin Lab. of Nat. His., State Univ. of Iowa, vol. III, No. 4.

The collections on which the notes are based are deposited in the herbarium of the State University of Iowa. To avoid repetition the dates of collecting are here given for the several localities:

Mason City—July 6–9, 1896.

Clear Lake—July 10th–13th.

Forest City, Lake Edwards and the northern part of Hancock county*—July 17th–21st.

Spirit and the Okoboji lakes—July 30th–August 3d.

Rock Rapids and Granite—August 3d–7th.

The following is an annotated list of the species which were collected:†

Nymphœa reniformis D. C. Found in Clear Lake and in the Big Sioux river near Granite. These localities have not been noted heretofore.

Nuphar advena Ait. f. Additional localities: Mason City, Forest City, Spirit Lake.

Myriophyllum spicatum L. Additional localities: Lake Okoboji, common. Mostly in bud. Clear Lake, very common. All in bud. Growing in two to four feet of water.

Myriophyllum heterophyllum Mx. Clear Lake. Rather more common than the preceding. Forest City, not common in Lime creek.

Utricularia vulgaris L. Rather rare at Forest City, in Lime creek.

Ceratophyllum demersum L. Very common in West Okoboji lake, forming beautiful branching tufts in water three to six feet deep.

Elodea canadensis Mx. Very common in Lake Edwards and in the Okoboji lakes. New localities: Rock Rapids, in Rock river. Not common. Clear Lake, very common.

Vallisneria spiralis L. This interesting species was very common in Clear Lake, especially at the west end, but none were found in flower.

In Spirit Lake, along the western shore, small specimens of pistillate plants were collected in shallow water. These grew on a gravelly bottom.

A splendid lot of specimens were collected at the lower end of East Okoboji lake, near its juncture with the west lake. The leaves ranged in length from one to at least four feet, and

* Partly made in September, 1895.

† For convenience in making comparisons the nomenclature is largely that of Mr. Cratty's paper.

hundreds of pistillate flowers in all stages of development were found. A fine series of the staminate flowers were collected. These, so far as observed, were restricted to a small area, seemingly not more than a square yard in extent, in which staminate flowers only were found. These were at a depth of about two feet, growing like the others on a mud bottom.

Heteranthera graminea Vahl. This species is distributed throughout the state. It was common at Mason City, Forest City, Lake Edwards, Lake Okoboji, Rock Rapids, in Rock river, and in the Big Sioux river near Granite.

Spirodela polyrrhiza Schleid. Common at Forest City in Lime creek.

Lemna trisulca L. Very common in Lake Edwards, and also found at Forest City.

Lemna minor L. Abundant in the Big Sioux river near Granite, and in Rock river at Rock Rapids.

Potamogeton natans L. Not rare in the west end of Clear lake. Some were in fruit, others in flower. Specimens collected in Spirit lake were finely fruited.

Potamogeton nuttallii Cham. and Schl. This rare species, which has hitherto been reported in Iowa only from Muscatine county, was found in a small pond in northern Hancock county south of Forest City near the intersection of the Minneapolis & St. Louis railroad and the Burlington, Cedar Rapids & Northern railroad. It was mostly in fruit. A month later Mr. Cratty collected it in fine fruit at the same place.

Potamogeton spirillus Fuck. Found with the preceding. The species had been reported from Muscatine and Poweshiek counties. It is rare.

Potamogeton lonchites Fuck. This was common, in flower, in the Big Sioux near Granite, and in Rock river at Rock Rapids. The submersed leaves were abundant.

Potamogeton amplifolius Fuck. Common in the west end of Clear lake, mostly in flower. A form with narrower, nearly green leaves was not rare. Common and well fruited in Lake Okoboji and Spirit lake. Rare in Rock river at Rock Rapids.

Potamogeton prœlongus Wnef. Rather common in Clear lake. Fine specimens, 8 or 10 feet long, were abundant in deep water. Rare in East Okoboji lake. No flowers or fruit were collected.

Potamogeton perfoliatus L., var. *richardsonii* A. Benner. Common in flower in the west end of Clear lake. Very abundant in Okoboji lakes in flower and fruit. A form found in Spirit

lake, growing on gravelly bottom along the west shore, approaches the type in the character of the leaves.

Potamogeton zosteræfolius Schum. Common in Clear lake, in flower. Also common in Lake Edwards. Common in the Okoboji lakes, some finely fruited, but most of them in flower. Not common in Rock river at Rock Rapids.

Potamogeton foliosus Raf. Abundant in Lime creek near Forest City, mostly in flower. Mr. Cratty found it a month later in fine fruit.

Potamogeton major (Fries) Morong. Common in Clear lake, some in fruit, but most of it in flower. Very common in the Okoboji lakes at their juncture. In good fruit, but flowering specimens were common.

Potamogeton pussillus L. Rare in Clear lake at west end. Some in fruit, others flowering. Not common in East Okoboji lake near its northern extremity. The glands at the base of the leaf are well shown in most of the specimens.

Potamogeton pectinatus L. Common, mostly in flower, in Clear lake. The specimens growing on sandy bottom at the east end of the lake were slender and few-leaved. Also common in Lake Edwards. Very fine and in excellent fruit in East Lake Okoboji. Rare in Rock river near Rock Rapids.

Nais flexilis (Willd) R. & S. Very common in rather shallow water in Lake Edwards, Clear lake and Spirit. Growing on sandy or mud bottoms.

Zannichellia palustris L. Quite common and in fruit in shallow water on gravelly bottom along the west shore of Spirit lake. Much finer specimens were found in East Okoboji lake in somewhat deeper water. The leaves were in excellent condition for collecting, and many species of aquatic plants which seldom fruit were found in splendid condition. The following algæ, identified by Miss Lucy M. Cavanagh were also collected:

Chætophora pisiformis (Roth) Ag. Common in West Lake Okoboji.

Chætophora monolifera Kg. Common on *Cladophora* in Clear lake. New to the state.

Cladophora obigoclona Kg. Common in Clear lake.

Cladophora glomerata Kg. var. Common in West Lake Okoboji.

Cladophora fracta Kg. Common in West Lake Okoboji.

Cladophora fracta var. *gossypina* Kg.(?) Common in West Lake Okoboji.

Cladophora fracta Kg. var. In West Lake Okoboji.

Hydrodictyon utriculatum. Very common in Lime creek, at Forest City.

SPERMAPHYTA OF THE FLORA OF FAYETTE, IOWA.

BRUCE FINK.

INTRODUCTION.

A considerable amount of work has been done on the flora of the vicinity of Fayette since the early settlement, and during the last five years the writer has explored the region thoroughly. Nearly 200 of the plants of this list have been carefully compared by the writer and other persons at the herbaria of the University of Minnesota and Harvard university. I have also had the aid of specialists on five difficult genera, and altogether the list of a few more than 700 species and varieties has been carefully worked out.

The early work was done by Dr. C. C. Parker who, previous to 1876, had collected and preserved nearly 500 specimens of our herbaceous plants. Dr. Parker's herbarium contains twenty-eight plants not found by the writer, which are listed. They may be known, as he is given credit for the collecting. I am also indebted to him for the use of his herbarium in preparing this record, and for valuable aid in finding several rare plants.

As to territory covered, the list is approximately complete for the region within five miles of Fayette. A few plants are included which were collected ten or fifteen miles away, but the work is doubtless quite incomplete for some portions of Fayette county. This region furnishes a good field for the study of the higher plants, as the topographical features are quite varied. Prairies, woods, rivers, springs, marshes, ponds, hills and limestone ledges all abound. The woods, even after so much clearing has been done, are a more inviting field for study than the limited amount of unbroken prairie. Twenty years ago the prairie grasses and sedges were surely much more abundant than now, but unfortunately they were not

studied till quite recently, after the prairies had been largely brought under cultivation. This accounts for the small number of grasses and sedges listed, after I have collected them as carefully as other genera—except the genus *Carex*, which needs more study.

I wish to express my thanks to Dr. B. L. Robinson, and to Prof. Conway MacMillan, for the use of the herbaria mentioned above, in comparing plants. The late Mr. M. S. Bebb named the species of *Salix*, Mr. M. L. Fernald those of *Carex* (except four species collected by Mr. A. S. Skinner and Miss Ona M. Rounds in 1896, which were determined by Mr. R. I. Cratty), Prof. C. S. Sargent those of *Quercus*, and Mr. R. I. Cratty those of *Sagittaria* and *Potamogeton*. Mr. A. A. Heller and Mr. J. W. Blankinship also aided in the determination of a number of species. To all of these gentlemen I am greatly obliged for the aid freely given.

That the unrest in botanical synonomy is to continue for some time is certain, if, indeed, all features of it can be permanently settled. I have used the arrangement and synonomy of Gray's Manual, sixth edition, which doubtless is not to stand long without radical change. The work has grown up under this system, and it will serve its purpose so that this record can be used in the future study of this vicinity or a somewhat larger one. Furthermore, this manual has commonly been used in Iowa in making general lists.

The plants herein recorded will be found in the herbaria of the persons who are credited with the collections. The herbarium of the Upper Iowa university contains nearly all the species also, and the writer has collected 640 of them for the United States National Herbarium. These last were delivered in 1894.

Nearly all the species listed were collected by the writer. Other collectors are given credit for the plants collected by them. Besides, Dr. C. C. Parker, Mr. J. R. Gardner, Mr. A. S. Skinner, Mr. R. B. Wylie, Miss Gem E. Rounds, Miss Ona M. Rounds, Miss Etna Burrette and Mr. W. F. Baker have each added to the work by their collecting. I am under obligations to all of them for this help.

Several species are herein reported for the first time in Iowa, as is indicated with the names of these plants. Further study of this vicinity will bring out new information regarding the families here treated. If this list shall aid in such investiga-

tion or prove helpful to the botanists of other parts of Iowa, I shall feel well rewarded for the many days spent in collecting and studying the plants and in the final preparation of this paper.

LIST OF SPECIES.

RANUNCULACEÆ.

Clematis virginiana L. Banks and low thickets, infrequent.

Anemone patens L., var. *nuttalliana* Gray. High prairies, common.

A. caroliniana Walt. Prairies, rare.

A. cylindrica Gray. Woods, frequent.

A. pennsylvanica L. Low prairies, common.

A. nemerosa L. Dry woods, common.

Hepatica acutiloba D. C. Woods, common. *H. triloba* Chaix is frequently reported here, but does not occur.

Anemonella thalictroides Spach. Woods, abundant.

Thalictrum dioicum L. Woods, common.

T. purpurascens L. Low prairies, infrequent.

Ranunculus circinatus Sibth. Ponds, probably rare. The leaves are sessile or nearly so, have stipules and are more rigid than those of the next.

R. aquatilis L., var. *trichophyllus* Gray. Ponds, infrequent. Coll. Mr. R. B. Wylie.

R. multifidus Pursh. Ponds, rare.

R. rhomboidens Goldie. Prairies, frequent.

R. abortivus L. Low open woods, common.

R. fascicularis Muhl. High prairies and open woods. Common.

R. septentrionalis Poir. Borders of swamps; infrequent.

R. hispidus Hook. Woods, apparently frequent; but probably *R. repens* L. or *R. pennsylvanicus* L. occurs and has been confused with the above. Not before reported in Iowa.

Isopyrum biternatum Torr. and Gray. Low woods, frequent.

Caltha palustris L. Wet ground, infrequent.

Aquilegia canadensis L. Along bluffs, frequent.

Delphinium exaltatum Ait. Low prairies, rare.

D. ajacis L. Sparingly escaped.

Actœa spicata L. var. *rubra* Ait. Woods, frequent.

A. alba Bigel. Woods along bluffs, rare.

Hydrastis canadensis L. Rich woods, rare.

MENISPERMACEÆ.

Menispermum canadense L. Along sandy river banks, rare.

BERBERIDACEÆ.

Caulophyllum thalictroides Michx. Woods, frequent.

Podophyllum peltatum L. Woods, common.

NYMPHÆACEÆ.

Nymphœa odorata Ait. Ponds, infrequent.

Nuphar advena Ait. Ponds, infrequent.

PAPAVERACEÆ.

Sanguinaria canadensis L. Woods, common.

FUMARIACEÆ.

Dicentra cucullaria Torr. Woods, common.

D. canadensis Gray. Woods, rare. Fruit collected here in 1894 by Miss Etna Burrette. Only reported elsewhere in Iowa by Mr. E. W. D. Holway, at Decorah. Single spot a few rods square known here.

CRUCIFERÆ.

Dentaria laciniata Muhl. Woods, common.

Cardamine rhomboidea D. C. Wet ground, common.

C. hirsuta L. Wet ground, frequent.

Arabis lœvigata Poir. Wooded hillsides, rare. Leaves usually entire except those at the base.

A. canadensis L. Open woods, frequent.

A. dentata Torr. and Gray. River banks, frequent.

Draba caroliniana Walt. Waste ground, infrequent.

D. caroliniana Walt., var. *micrantha* Gray. Waste ground, common.

Nasturtium officinale R. Br. Streams and springs, rather rare.

N. palustre D. C. Wet ground, frequent.

N. armoracia Fries. Escaped, rare.

Hesperis matronalis L. Escaped, rare.

Erysimum cheiranthoides L. Low ground, infrequent.

Sisymbrium canescens Nutt. A single spot known here in a sandy opening.

S. officinale Scop. Waste ground, common.

Thelypodium pinnatifidum Watson. River banks, rare.

Brassica nigra Koch. Waste ground, common.

Capsella bursa-pastoris Mœnch. Waste ground, common.

Lepidum intermedium Gray. Waste ground, common.

CAPPARIDACEÆ.

Polanisia graveolens Raf. (?) Probably *P. trachyspermum* Torr. and Gray. Sandy ground, rare.

CISTACEÆ.

Helianthemum canadense Michx. Dry hills, infrequent.

Lechea minor L. Dry prairies, infrequent.

VIOLACEÆ.

Viola pedata L. Prairies and open woods, common.

V. pedatifida Don. Prairies, frequent.

V. palmata C., var. *cucullata* Gray. Low prairies, common.

V. sagittata Ait. Found only in the first railroad cut two miles south of Fayette.

V. blanda Willd. Moist prairies, rare. Mr. W. F. Baker, coll.

V. pubescens Ait. Woods, common.

V. tricolor L. Rarely escaped.

CARYOPHYLLACEÆ.

Saponaria officinalis L. Frequently escaped.

Silene stellata Ait. Woods, frequent.

S. nivea Otth. Low prairies and woods, frequent.

S. antirrhina L. Dry ground, frequent.

S. noctiflora L. Rarely escaped.

Lychnis githago Lam. In fields, rare.

Arenaria michauxii Hook. Dry prairies, infrequent.

A. lateriflora L. Low prairies, rather infrequent.

Stellaria media Smith. Low woods, infrequent.

S. longifolia Muhl. Borders of swamps, rare.

Cerastium vulgatum L. Dr. C. C. Parker, coll. Marked in herb. *C. viscosum* L.

C. arvense L., var. *oblongifolium* Britt and Hall. Dry woods, rare.

PORTULACACEÆ.

Portulaca oleracea L. Cultivated and waste ground, abundant.

Claytonia virginica L. Moist woods, common.

HYPERICACEÆ.

Hypericum ascyron L. Banks of streams, infrequent.

H. maculatum Walt. Wet prairies, frequent.

H. canadense L., var. *majus* Gray. Banks and low prairies, common.

Elodes campanulata Pursh. Borders of swamps, infrequent.

MALVACEÆ.

Malva rotundifolia L. About yards, frequent.

M. sylvestris L. About yards, rare. Also collected by Dr. C. C. Parker.

Napœa dioca L. Low sandy soil, very rare.

Abutilon avicennœ Gærtn. Waste ground, frequent.

Hibiscus trionum L. Waste ground, rare.

TILIACEÆ.

Tilia americana L. Woods, frequent.

LINACEÆ.

Linum sulcatum Riddell. Dry prairies, frequent.

L. usitatissimum L. Occasionally escaped.

GERANIACEÆ.

Geranium maculatum L. Woods, common.

G. carolinianum L. Waste ground; only two plants have been collected here.

Oxalis violacea L. Waste ground, etc., abundant.

O. corniculata L., var. *stricta* Sav. Woods and waste ground, common.

Impatiens pallida Nutt. Wet shady places, frequent.

I. fulva Nutt. With the last, frequent.

FUTACEÆ.

Xanthoxylum americanum Mill. Woods, common.

CELASTRACEÆ.

Calastrus scandens L. Wooded river banks, infrequent.

Euonymus atropurpureus Jacq. Woods, rare.

RHAMNACEÆ.

Ceanothus americanus L. Open woods, common.

VITACEÆ.

Vitis riparia Michx. River banks and low woods, common.

Ampelopsis quinquefolia Michx. Woods, infrequent.

SAPINDACEÆ.

Acer saccharinum Wang. Woods, common.

A. saccharinum Wang., var *nigrum* Torr. and Gray. A single tree known in low woods.

A. dasycarpum Ehrh. River banks, infrequent.

Negundo aceroides Mœnch. Low woods, infrequent.

Staphylea trifolia L. Woods, infrequent.

ANACARDIACEÆ.

Rhus typhina L. Common five miles east of Fayette. Probably rare further west in Iowa.

R. glabra L. Woods, common. The form with laciniate leaves is represented by a specimen (herb. Dr. C. C. Parker) marked *var. laciniata.*

R. toxicodendron L. Rocky river banks, common. The climbing form, *R. radicans* L., has been noticed but once.

POLYGALACEÆ.

Polygala senaga L. Woods, common.

P. incarnata L. Dry ground, rare. Dr. C. C. Parker, coll.

P. sanguinea L. Prairies, common.

P. verticillata L. Prairies, probably rare. Dr. C. C. Parker, coll.

LEGUMINOSÆ.

Baptisia leucophæa Nutt. Prairies, frequent.

B. leucantha Torr. and Gray. Prairies, frequent.

Trifolium pratense L. Cultivated and spontaneous, common.

T. repens L. Cultivated and spontaneous, common.

T. procumbens L. Rare. Dr. C. C. Parker, coll.

Melilotus officinalis Willd. Waste ground, rare.

M. alba Lam. Waste ground, infrequent.

Amorpha canescens Pursh. Prairies, infrequent.

A. fruticosa L. River banks, frequent.

Petalostemon violaceus Michx. Prairies, common.

P. candidus Michx. Prairies and open woods, common.

Tephrosia virginiana Pers. Rare. Collected by Miss Gem E. Rounds near Clermont.

Robinia pseudacacia L. Cultivated and rarely escaped.

Wistaria frutescens Poir. (?) Rare. Miss Gem E. Rounds, coll., whose specimen was too fragmentary for certain determination. Whether this or not, the plant is no leguminous plant ever reported in Iowa.

Astragalus caryocarpus Ker. Prairies, frequent.

A. canadensis L. Borders of woods, infrequent.

Desmodium acuminatum D. C. Woods, common.

D. illinoense Gray. Prairies, frequent.

D. paniculatum D. C. Low prairies, rare. Approaches *D. dillenii*, Darl.

D. canadense D. C. Woods and prairies, common.

D. sessilifolium Torr. and Gray. Prairies, infrequent.

Lespedeza leptostachya Engelm. Dry woods, a single specimen collected.

L. capitata Michx. Prairies, frequent.

Vicia caroliniana Walt. River banks, rare. Dr. C. C. Parker, coll.

V. americana Muhl. River banks, rare.

Lathyrus ochroleucus Hook. Prairies along borders of woods, rare.

L. venosus Muhl. Wooded hillsides, frequent.

L. palustris D. Borders of swamps, infrequent.

Amphicarphæ monoica Nutt. Woods, probably rare. Dr. C. C. Parker, coll.

A. pitcheri Torr. and Gray. Woods, probably common, First reported in 1892 by Prof. B. Shimek, Bull. Lab. Nat. Hist, State University 3: 202. F. 1896. Mr. R. B. Wylie showed me the same species from Jackson county.

Cassia chamæcrista L. Sandy ground, frequent.

Gymnocladus canadensis Lam. Woods, rare. Dr. C. C. Parker, coll., who has a tree in his yard transplanted from the woods.

Gleditschia tricanthos L. Woods, rare.

ROSACEÆ.

Prunus americana Marsh. Thickets and woods, frequent.

P. pennsylvanica L. Woods, rare.

P. virginiana L. Woods, frequent.

P. serotina Ehrh. Woods, infrequent.

Spiræ salicifolia L. Low prairies, frequent.

Physocarpus opulifolius Maxim. Rocky banks, frequent.

Rubus strigosus Michx. Woods, infrequent.

R. occidentalis L. Woods, frequent.

R villosus Ait. Woods, infrequent.

Geum album Gmelin. Woods, frequent.

G virginianum L. Woods and borders, infrequent.

G. triflorum Pursh. Dry hills, rare.

G. strictum Ait. Low ground, rare. Dr. C. C. Parker, coll.

Fragaria virginiana Mill., var. *illinoensis* Gray. Low prairies and woods, common.

F. vesca L. Rocky ground, infrequent.

Potentilla arguta Pursh. Prairies, frequent.

P. norvegica L. Low ground near streams, common.

P. rivalis Nutt. Sandy ground, probably rare.

P. canadensis L. Waste ground and open woods, common.

Agrimonia eupatoria L. Woods, common.

Rosa blanda Ait. Prairies and open woods, common.

R. arkansana Porter. Prairies, rare.

Pyrus coronaria L. Woods, frequent.

Cratægus coccinea L. Woods, common. Varieties may occur.

C. punctata Jacq. Woods, frequent.

C. tomentosa L. (?) Woods, infrequent. Plant collected not satisfactory.

Amalanchier canadensis Torr. and Gray. Along streams, frequent.

A. canadensis Torr, and Gray, var. *oblongifolia* Torr. and Gray. With the last, infrequent.

SAXIFRAGACEÆ.

Saxifraga pennsylvanica L. Low prairies, common.

Mitella diphylla L. High woods, common.

Heuchera hisrida Pursh. Prairies, common.

Prrnassia caroliniana Michx. River banks, rare.

Ribes cynosbati L. Woods, frequent.

R. gracile Michx. Woods, frequent.

R. floridum L'Her. Woods, infrequent.

CRASSULACEÆ.

Penthorum sedoides L. Wet ground, frequent.

UMAERLLIFERÆ.

Lythrum alatum Pursh. Low ground, common.

ONAGRACEÆ.

Ludwigia polycarpa Short and Peter. Borders of swamps, infrequent.

L. palustris Ell. Swamps, common.

Epilobium lineare Muhl. Bogs, rare.

E. coloratum Muhl. Low ground, common.

Oenothera biennis L. Waste ground, frequent.

Oe. rhombipetala Nutt. Dry soils, infrequent.

Oe. serrulata Nutt. Dry prairies, frequent.

Circœa lutetiana L. Woods, common.

CUCURBITACEÆ.

Echinocystis lobata Torr. and Gray. Banks of streams, infrequent.

FICOIDEÆ.

Mollugo verticillata L. Sandy ground, common.

UMBELLIFERÆ.

Daucus carota L. Occasionally escaped.

Heracleum lanatum Michx. Woods and openings, frequent.

Pastinaca sativa L. Occasionally escaped.

Thaspium aureum Nutt. Low prairies and woods, frequent.

Pimpinella integerrima Benth. and Hook. Rocky hills, rather rare.

Cryptonœnia canadensis L. Woods, common.

Sium cicutæfolium Gmelin. Low prairies, frequent.

Carum carui L. Frequently escaped.

Cicuta maculata L. Borders of ponds, infrequent.

Osmorrhiza brevistylis DC. Woods, frequent.

O. longistylis DC. Woods, frequent.

Eryngium yuccæfolium Michx. Low prairies, common.

Sanicula marylandica L. Woods, common.

ARALIACEÆ.

Aralia racemosa L. Woods, infrequent.

A. nudicaulis L. Woods, frequent.

A. quinquefolia D. and Planch. Woods, rare.

CORNACEÆ.

Cornus circinata L'Her. Woods, frequent.

C. sericea L. Low woods, infrequent.

C. stolonifera Michx. Low grounds, rare.

C. paniculata L'Her. Wooded river banks, frequent.

C. alternifolia L. Wooded river banks, infrequent.

CAPRIFOLIACEÆ.

Adoxa moschatellina L. Growing about old stumps, rare. Only other locality known in Iowa is at Decorah, where Mr. E. W. D. Holway finds it.

Sambucus canadensis L. Low woods and clearings, frequent.

S. racemosa L. (?) Dr. C. C. Parker says this plant has occurred here, but I have not seen a specimen.

Viburnum opulus L. River banks, rare.

V. pubescens Pursh. Rocky woods, infrequent.

V. lentago L. Woods and clearings, frequent.

Triosteum perfoliatum L. Woods, common.

Symphoricarpos occidentalis Hook. Borders of woods and prairies, infrequent.

Lonicera tartarica L. Two or three plants along the Volga river.

L. sullivantii Gray. Woods, common.

L. glauca Hill. Woods, common.

Diervilla trifida Mœnch. A single plant was collected along the Volga river by Mr. A. S. Skinner. Elsewhere reported in Iowa only at Decorah by Mr. E. W. D. Holway.

RUBIACEÆ.

Galium aparine L. Low woods, common.

G. boreale L. Low prairies and banks of streams, common.

G. trifidum L. Low ground, common.

G. trifidum L., var. *latifolium* Torr. Low ground, infrequent.

G. triflorum Michx. Woods, frequent. May be *G. asprellum* Michx. instead.

VALERIANACEÆ.

Valeriana edulis Nutt. Wet prairies, common.

COMPOSITÆ.

Veronia fasciculata Michx. Low ground, frequent.

Eupatorium purpureum L. Low ground, common.

E. serotinum Michx. Borders of woods, rare.

E. altissimum L. Dry ground, infrequent.

E. perfoliatum L. Low ground, common.

E. ageratoides L. Woods, common.

Kuhnia eupatorioides L. Dry prairies, abundant.

K. eupatorioides L., var. *corymbulosa* Torr. and Gray. With the last, probably frequent.

Liatris cylindrica Michx. Prairies, common.

L. scariosa Willd. Prairies, frequent.

L. pycnostachya Michx. Prairies, common.

Solidago latifolia L. Woods, common.

S. speciosa Nutt. Dr. C. C. Parker, coll., probably rare.

S. ulmifolia Muhl. Open woods and prairies, frequent.

S. missouriensis Nutt. Prairies, infrequent.

S. serotina Ait. Prairies, infrequent.

S. serotina Ait., var. *gigantea* Gray. Prairies, common.

S. nemoralis Ait. Dry prairies, infrequent.

S. canadensis L. Prairies, common.

S. rigida L. Dry prairies, common.

S. lanceolata L. Low prairies, infrequent. Dr. C. C. Parker and Mr. J. R. Gardner have both collected the plant.

Aster oblongifolius Nutt., var. *rigidulus* Gray. Dry prairies, rare.

A. novæ-angliæ L. Low prairies, frequent.

A. sericeus Vent. High prairies, frequent.

A. shortii Hook. Prairies, rare. Has the hary petioles of *A. azureus* Lindl., and the leaves are also slightly pubescent above.

A. undulatus L. Prairies. J. R. Gardner, coll. Specimen not very satisfactory.

A. cordifolius L. Borders of woods, infrequent.

A. sagittifolius Willd. Borders and open woods, common.

A. lævis L. Prairies and open woods, common.

A. multiflorus Ait. Dry prairies, abundant.

A. diffusus Ait. Low ground, common,

A. paniculatus Lam. Low ground, abundant.

A. novi-belgii L. (?) Dr. C. C. Parker, coll. Specimen fragmentary.

A. prenanthoides Muhl. Low ground, rather rare.

A. umbellatus Mill. Low woods and prairies, frequent.

Erigeron canadensis L. Waste ground, abundant.

E. annuus Pers. Waste ground, common.

E. strigosus Muhl. Waste ground, frequent.

E. bellidifolius Muhl. Moist woods, common.

E. philadelphicus L. Moist woods, frequent.

Antennaria plantaginifolia Hook. High woods and prairies, common.

Gnaphalium polycephalum Michx. Fields and open woods, frequent.

Polymnia canadensis L. Shaded moist places, infrequent.

Silphium laciniatum L. Prairies, common.

S. integrifolium Michx. Low prairies and open woods, frequent.

S. perfoliatum L. Along streams, infrequent.

Parthenium integrifolium L. Prairies and open woods, common.

Ambrosia trifida L. Moist ground, common.

A. trifida L., var. *integrifolia* (Muhl.) Torr. and Gray. With the last or in dry places, infrequent.

A. artemisiæfolia L. Waste ground, abundant.

A. psilostachya D. C. Waste ground, only two small patches known here.

Xanthium canadense Mill. Waste ground, frequent.

Heliopsis scabra Dunal. Prairies, frequent.

Echinacea augustifolia DC. Prairies, frequent.

Rudbeckia laciniata L. Low ground, common.

R. triloba L. Dry prairies, common.

R. subtomentosa Pursh. Prairies, infrequent. Dr. C. C. Parker, coll.

R. hirta L. Prairies, frequent.

Lepachys pinnata Torr. and Gray. Prairies, common.

Helianthus annuus L. Waste ground, infrequent.

H. rigidus Desf. Prairies, frequent.

H. occidentalis Riddell. Prairies, common.

H. lætiflorus Pers. Prairies, rare. Dr. C. C. Parker, coll.

H. grosse-serratus Martens. Prairies, frequent. One plant placed here after comparison must be a very unusual form, or a different species; others are the usual form.

H. giganteus L. Low ground, rare.

H. giganteus L, var. *ambiguus* Torr. and Gray. Prairies, frequent. The plant may be *H. maximiliani* Shrad. instead.

H. divaricatus L. (?) Dr. C. C. Parker, coll. Specimen not certain.

H. hirsutus Raf. Dry prairies, frequent.

H. strumosus L. Low ground, frequent.

H. tracheliifolius Willd. Low thickets, rare.

H. tuberosus L. Prairies and borders, frequent.

Coreopsis palmata Nutt. Prairies, common.

Bidens frondosa L. Low ground, abundant.

B. connata Muhl. Wet ground, common.

B. connata Muhl., var. *comosa* Gray. With the last, frequent.

B. cernua L. Wet ground, probably common. Dr. C. C. Parker, coll.

B. chrysanthemoides Michx. Wet ground, frequent.

Helenium autumnale L. Moist ground, common.

Anthemis cotula L. Waste ground, abundant.

Achillea millefoliun L. Prairies, common.

Tanacetum vulgare L. Occasionally escaped.

Artemisia caudata Michx. Sandy soil, common.

A. dracunculoides Pursh. Sandy river banks, infrequent.

A. serrata Nutt. Low prairie, rare.

A. ludoviciana Nutt. Prairie, common and variable.

A. biennis Willd. Sandy soil, rare. Dr. C. C. Parker, coll.

A. absinthium L. Rarely escaped. Dr. C. C. Parker, coll.

Senecio aureus L. Low ground, common.

S. aureus L., var. *balsamitæ* (Muhl.) Tarr. and Gray. With the last, probably rare.

Cacalia suaveolens L. Borders of woods, infrequent.

C. reniformis Muhl. Open damp woods, frequent.

C. tuberosa Nutt. Low prairies, frequent.

Erechtites hieracifolia Raf. Moist ground, rare. Dr. C. C Parker, coll.

Arctium lappa L. Waste ground, common. Probably varieties occur.

Cnicus lanceolatus Hoffm. Pastures and waste ground, common.

C. Altissimus Willd. Low woods, frequent.

C. Altissimus Willd., var. *discolor* Gray. Waste ground, frequent.

C. Arvensis Hoffm. Mr. C. F. Paine reports this plant from two places in Fayette county.

Krigia amplexicaulis Nutt. Woods, common.

Cichorium intybus L. Roadsides, infrequent.

Tragopogon pratensis L. A single specimen collected in a street of Fayette. Not before reported in Iowa.

Hieracium canadense Michx. Open woods and prairies, frequent.

H. scabrum Michx. Woods, rare. Mr. R. B. Wylie, coll.

Prenanthes racemosa Michx. Low prairies, infrequent

P. aspera Michx. Prairies, rare. Dr. C. C. Parker, coll.

P. alba L. Woods and borders, frequent.

Troximon cuspidatum Pursh. High prairies, rare.

Taraxacum officinale Weber. Pastures, yards, etc., abundant.

Lactuca scariola L. Waste ground, rare. First collected in 1895. Will probably soon become common.

L. canadensis L. Waste ground, common.

L. floridana Gaertn. Rare. Dr. C. C. Parker, coll.

L. leucophœa Gray. Rare. Dr. C. C. Parker, coll.

Sonchus oleraceus L. Waste ground, common.

S. asper Vill. Waste ground, rare or confused with the above. Dr. C. C. Parker, coll.

LOBELIACEÆ.

Lobelia cardinalis L. Along streams, rarely occurs in the western part of Fayette county.

L. syphilitica L. Low ground, common.

L. spicata Lam. Prairies, frequent.

L. spicata Lam., var. *hirtella* Gray. With the last, seldom observed.

L. inflata L. Open woods and borders, infrequent.

CAMPANULACEÆ

Specularia perfoliata A. D. C. Open woods, frequent.
Campanula rotundifolia L. Rocky places, common.
C. aparinoides Pursh. Borders of swamps, infrequent.
C. americana L. Moist places, common.

ERICACEÆ.

Chimaphila umbellata Nutt. Woods, only a dozen plants known in one place.
Pyrola elliptica Nutt. Woods, common.
Monotropa uniflora L. Woods, rare.

PRIMULACEÆ.

Dodecatheon media L. Prairies, common.
Steironema ciliatum Raf. Low ground, common.
S. lanceolatum Gray. Low ground, common.
S. longifolium Gray. Low ground, common.
Lysimachia stricta Ait. Low ground, rare.
L. thyrsiflora L. Swamps, rare.

OLEACEÆ.

Fraxinus americana L. Woods, infrequent.
F. viridis Michx. Low woods, apparently rare.
F. quadrangalata Michx. A single tree known to me.

APOCYNACEAE.

Apocynum androsæmifolium L. Borders of woods, common.
A. cannabinum L. Moist ground, common.

ASCLEPIDACEÆ.

Asclepias tuberosa L. Prairies, common.
A. incarnata L. Low ground, common.
A. cornuti Decaisne. Waste ground, common.
A. sullivantii Engelm. Low ground, frequent.
A. phytolaccoides Pursh. Low ground, rare.
A. ovalifolia Decaisne. Prairies, rare. Dr. C. C. Parker, coll.
A. verticillata L. Prairies, infrequent.
Acerates longifolia Ell. Prairies, infrequent.
A. viridiflora Ell., var. *lanceolata* Gray. Prairies, rare.

GENTIANACEÆ.

Gentiana crinita Froel. Rare. Dr. C. C. Parker, coll., who assures me that the plant was common ten years ago. Mr. J R. Gardner collected it in 1896.

G. quinqueflora Lam., var. *occidentalis* Gray. Borders of woods, becoming common.

G. puberula Michx. Dry prairies, rare.

G. andrewsii Griseb. Low prairies, infrequent.

G. alba Muhl. Low ground, rare.

POLEMONIACEÆ.

Phlox paniculata L. Rare and probably escaped. Mr. J. R. Gardner, coll.

P. maculata L. Low ground, infrequent.

P. pilosa L. Low prairies, common.

P. divaricata L. Woods, common.

P. subulata L. In cemetery, probably escaped.

Polemonium reptans L. Woods, abundant.

HYDROPHYLLACEÆ.

Hydrophyllum virginicum L. Woods, abundant.

H. appendiculatum Michx. Low woods, rare.

Ellisia nyctelea L. Moist, shady ground, common.

BORRAGINACEÆ.

Echinospermum virginicum Lehm. Woods, common.

E. lappula Lehm. Waste ground, common.

Mertensia virginica (L.) D. C. Woods, abundant.

Lithospermum officinale L. Border of woods, one patch known. Not previously reported in Iowa.

L. latifolium Michx. Rare, Dr. C. C. Parker, coll.

L. hirtum Lehm. Prairies, infrequent.

L. canescens Lehm. Prairies, common.

L. angustifolium Michx. High prairies, common. The form formerly considered a distinct species under the name of L. *longiflorum* Spreng, occurs commonly on hillsides and is quite distinct.

Onosmodium carolinianum A. D. C., var. *molle* (Michx.) Gray. Waste ground, common.

CONVOLVULACEÆ.

Ipomœa coccinea L. Rarely escaped.

I. purpurea Lam. Frequently escaped.

Convolvulus sepium L. Low ground, frequent.

C. arvensis L. In yards, rare.

Cuscuta inflexa Engelm. On various plants, infrequent.

C. tenuiflora Engelm. On willows in low ground, frequent.

C. glomerata Choisy. Low ground, probably rare. Mr. J. R. Gardner, coll.

SOLANACEÆ.

Solanum triflorum Nutt. A single plant collected along the Volga river in 1895. Not before reported in Iowa.

S. nigrum L. Low ground, common.

S. heterodoxum Dunal. Growing along a street in Fayette. Doubtless introduced. Not before reported in Iowa.

Physalis philadelphica L. A single plant collected in a field in 1896.

P. pubescens L. Waste ground, common.

P. virginiana Mill. Waste ground, frequent.

P. lanceolata Michx. Waste ground, infrequent.

Datura stramonium L. Waste ground, infrequent.

D. tatula L. Waste ground, infrequent.

SCROPHULARIACEÆ.

Verbascum thapsus L. Waste ground, frequent.

Linaria vulgaris Mill. Waste ground, infrequent.

Scrophularia nodosa L. var. *marilandica* Gray. Low prairies, common.

Chelone glabra L. Wet ground, frequent.

Mimulus ringens L. Wet ground, common.

Conobea multifida Benth. A single plant collected in 1894. Reported by J. C. Arthur from Lee county.

Gratiola virginiana L. Low ground, frequent.

Ilysanthes riparia Raf. Wet ground, common.

Synthyris houghtoniana Benth. Prairies, rare. Dr. C. C. Parker, coll.

Veronica virginica L. Woods and prairies, common.

V. anagallis L. About springs, infrequent.

V. peregrina L. Low waste ground, common.

Gerardia auriculata Michx. Low prairies, infrequent.

G. purpurea L. Low ground, common.

G. tenuifolia Vahl. Dry prairies, rare.

Castilleia coccinea Spreng. Woods and prairies, common. Flowers commonly yellow on the prairies.

C. sessiliflora Pursh. High prairies, infrequent.

Pedicularis canadensis L. Prairies and open woods, common.

P. lanceolata Michx. Moist woods, infrequent.

LENTIBULARIACEÆ.

Utricularia vulgaris L. Ponds, infrequent.

VERBENIACEÆ.

Verbena urticæfolia L. Low ground, common.

V. hastata L. Low ground, common.

V. stricta Vent. Prairies, frequent.

V. bracteosa Michx. Waste ground, common.

Phryma leptostachya L. Low woods, frequent.

LABIATÆ.

Isanthus cœruleus Michx. Dry hills, frequent.

Teucrium canadense L. Moist ground, abundant.

Mentha canadensis L. Moist ground, abundant.

Lycopus virginicus L. Moist ground, common.

L. sinuatus Ell. Moist ground, common.

Pycnanthemum lanceolatum Pursh. Prairies, infrequent.

Hedeoma pulegioides Pers. Dry hills, rare.

H. hispida Pursh. Dry ground, common.

Salvia lanceolata Willd. Specimen collected in 1894, but lost.

S. officinalis L. Persisting after cultivation.

Monarda fistulosa L. Prairies and woods, common.

Blephilia hirsuta Benth. Moist woods, infrequent.

Lopanthus nepetoides Benth. Borders of woods, infrequent.

L. scrophulariæfolius Benth. Borders of woods, infrequent.

Nepeta cataria L. Waste ground, common.

N. glechoma Benth. Yards, etc., common.

S. versicolor Nutt. River banks, infrequent.

Scutellaria lateriflora L. River banks, frequent.

S. parvula Michx. High prairies, frequent.

S. galericulata L. Wet shady ground, rare.

Brunella vulgaris L. Open woods and waste ground, common.

Physostegia virginiana Benth. Low ground, common.

Marrubium vulgare L. Probably escaped, rare. Dr. C. C. Parker, coll. Mr. R. B. Wylie also collected it in Jackson county in 1896. Not before reported in Iowa.

Leonurus cardiaca L. Yards, etc., frequent.

Stachys palustris L. Wet ground. Dr. C. C. Parker, coll.

S. aspera Michx. Wet ground. Dr. C. C. Parker, coll.

S. aspera Michx., var. *glabra* Gray. Wet ground. Dr. C. C. Parker, coll. Probably all three species of the genus are rare.

PLANTAGINACEÆ.

Plantago major L. Waste ground, common.

P. rugelii Decaisne. Waste ground, frequent.

P. lanceolata L. Yards, rare. Miss Gem E. Rounds, coll.

P. patagonica Jacq., var. *gnaphalioides* Gray. Sandy ground in western part of Fayette county and common in parts of Bremer county. Hitherto only reported from western Iowa. (Proc. Iowa Acad. Science, 3:129, 1895.)

NYCTAGINACEÆ.

Oxybaphus nyctagineus Sweet. Sandy river banks, frequent.

AMARANTACEÆ.

Amarantus albus L. Waste ground, common.

A. blitoides Watson. Waste ground, frequent.

A. retroflexus L. Cultivated fields, etc., frequent.

Acnida tuberculata Moq. Low waste ground, frequent.

CHENOPODIACEÆ.

Chenopodium boscianum Mcq. Waste ground, frequent.

C. album L. Waste ground, common.

C. hybridum L. Cultivated fields and waste ground, frequent.

C. bonus-henricus L. (?) Waste ground, rare. Specimen immature, carefully compared.

C. botrys L. Sandy river banks, rare.

Salsola kali L., var. *tragus* D. C. Introduced along the railroad. One specimen collected in 1895 and another in 1896. Likely to become common in a few years.

POLYGONACEÆ.

Rumex patientia L. A single patch known. Found in 1894 by Dr. C. C. Parker and the writer. New to Iowa. Determined by Mr. John K. Small.

R. altissimus Wood. Moist ground, frequent. *R. salicifolius* Weinmann may occur here also. The above determined by Mr. John K. Small.

R. verticillatus L. Swamps, rare.

R. crispus L. Waste ground, etc., common.

R. acetosella L. Waste ground, common.

Polygonum aviculare L Waste ground, abundant.

P. erectum L. Waste ground, common.

P. ramosissimum Michx. Moist, sandy ground, frequent.

P. lapathifolium L. Wet ground, frequent.

P. pennsylvanicum L. Moist ground, common.

P. muhlenbergii Watson. Swamps, rare.

P. orientale L. Escaped. Dr. C. C. Parker, coll.

P. persicaria L. Waste ground, frequent.

P. hydropiperoides Michx. Wet ground, infrequent.

P. hydropiper L. Moist ground, infrequent.

P. acre H B K Wet ground, common.

P. virginianum L. Rich woods, common.

P. sagittatum L. Moist ground, frequent.

P. convolvulus L. Waste ground and fields, common.

P. dumetorum L., var., *scandens* Gray. Moist thickets, infrequent.

Fagopyrum esculentum Mœnch. Occasionally escaped.

ARISTOLOCHIACEÆ.

Asarum canadense L. Wooded hillsides, frequent.

THYMELÆACEÆ.

Dirca palustris L. Dry prairies, common.

SANTALACEÆ.

Comandra umbellata Nutt.

EUPHORBIACEÆ.

Euphorbia serpyllifolia Pers. Waste ground, frequent. Seems to run into *E. glyptosperma* Engelm.

E. maculata L. Waste ground, common and variable.

E. preslii Guss. Waste ground, infrequent.

E. corollata L. Prairies and open woods, common.

E. heterophylla L. Rocky river banks, rare.

E. cyparissias L. Rarely escaped.

Acolypha virginica L. Waste ground, common.

URTICACEÆ.

Ulmus fulva Michx. Woods, frequent.

U. americana L. Low woods along streams, frequent.

U. racemosa Thomas. Several trees known in one place in low woods.

Celtis occidentalis L. Open woods along the Volga river, infrequent.

Cannabis sativa L. Waste ground, frequent.

Humulus lupulus L. Open woods, infrequent.

Urtica gracilis Ait. Moist ground, frequent.

Laportea canadensis Gaudichaud. Low moist woods, common.

Pilea pumila Gray. Low woods, frequent.

Bœhmeria cylindrica Willd. Low woods, frequent.

JUGLANDACEÆ.

Juglans cinerea L. Woods, frequent.

J. nigra L. Woods, frequent.

Carya alba Nutt. Woods, infrequent here, but common along streams in Bremer county.

C. amara Nutt. Woods, frequent.

CUPULIFERÆ.

Betula papyrifera Marshall. Woods, infrequent.

B. nigra L. Woods, frequent on the Turkey river.

Corylus americana Walt. Thickets and open woods, common.

Ostrya virginica Willd. Woods, frequent.

Carpinus caroliniana Walter. Woods, along streams, frequent.

Quercus alba L. Woods, frequent ten miles northeast of Fayette.

Q. macrocarpa Michx. Woods, common.

Q muhlenbergii Engelm. Woods on the Turkey river, infrequent.

Q. rubra L. Woods, frequent twelve miles northeast of Fayette.

Q. coccinea Wang. Woods, common.

Q. coccinea Wang., var. *tinctoria* Gray. Woods, infrequent.

SALICACEÆ.

Salix nigra Marsh. Along streams, frequent.

S. amygdaloides Anders. Low ground, frequent.

S. lucida Muhl. Low ground, frequent.

S. fragilis L., *X. alba* L. Low ground, rare and probably introduced and escaped. Not before reported in Iowa.

S. longifolia Muhl. Low ground, common.

S. rostrata Richardson. Low prairies, infrequent.

S. discolor Muhl., var. *prinoides* Anders. Low ground, common. Perhaps not the variety.

S. humilis Marsh. Prairies, frequent.

S. sericea Marsh. Low ground, frequent. Mr. Bebb expressed surprise at finding this here, especially a "pure form," which he said replaces *S. petiolaris* Smith.

S. sericea Marsh, *X. cordata* Muhl. Low ground, apparently frequent. *S. sericea* with serrate leaves. Not before reported in Iowa.

S. cordata Muhl. Low ground, rare.

S. cordata Muhl., *X. sericea* Marsh. Low ground. Not before reported in Iowa. Mr. Bebb wrote that *S. myricoides* Muhl. is a synonym. Leaves nearly entire and a different plant from the second above.

Populus tremuloides Michx. Woods, common.

P. grandidentata Michx. Woods, common.

P. monilifera Ait. Frequently coming up from seeds of planted trees. Dr. C. C. Parker feels sure that it occurs along our streams. If so, I have failed to notice it.

CERATOPHYLLACEÆ.

Ceratophyllum demersum L. Ponds infrequent.

CONIFERÆ.

Pinus strobus L. Woods, occasionally seen about Wadena.

Juniperus communis L. Wooded hills along streams, common.

J. virginiana L. At top of wooded bluffs, frequent.

Taxus canadensis Willd. At the base of wooded bluffs, frequent.

HYDROCHARIDACEÆ.

Elodea canadensis Michx. Ponds, infrequent.

Vallisneria spiralis L. In Volga river, rare.

ORCHIDACEÆ.

Aplectrum hiemale Nutt. Woods, frequent.

Spiranthes cernua Richard. Prairies, rare. Mr. J. R. Gardner, coll.

Calopogon pulchellus R. Br. Prairies at Wadena, rare.

Pogonia pendula Lindl. Rich woods, rooting in decayed wood and blooming in August or September, rare.

Orchis spectabilis L. Woods, frequent.

Habenaria tridentata Hook. Prairies at Wadena, rare. First reported for Iowa by the writer. Proc. Iowa Acad. Sci., 1: 103, 1893.

H. bracteata R. Br. Woods, rare.

H. hookeri Torr. Woods, rare.

H. hookeri Torr., var. *oblongifolia* Paine. Woods, rare. First reported for Iowa by the writer. Proc. Iowa Acad. Sci., 1: 103, 1893.

H. leucophæa Gray. Woods, rare. Dr. C. C. Parker, coll.

H. psycodes Gray. Woods, three plants collected in 1893. First reported for Iowa by the writer. Proc. Iowa Acad. Sci., 1: 103, 1893.

Cypripedium candidum Muhl. Low prairies, rare.

C. pubescens Willd. Woods, infrequent.

C. spectabile Salisb. Low woods and prairies, rare.

IRIDACEÆ.

Iris versicolor L. Wet prairies about ponds, frequent.

Sisyrinchium angustifolium Mill. Low prairies, common.

AMARYLLIDACEÆ.

Hypoxis erecta L. Prairies, common.

DIOSCOREACEÆ.

Dioscorea villosa L. A single plant was collected in 1894 along border of woods.

LILIACEÆ.

Smilax herbacea L., var. *pulverulenta* Gray. Woods, rare.

S. ecirrhata Watson. Woods, frequent. Apparently uncommon in Iowa as it was not reported till 1896. Prof. B. Shimek in Bull. Lab. Nat. Hist. Iowa State University, 3: 199, F. 1896. Our most common smilax.

S. hispida Muhl. Moist woods, infrequent.

Allium tricoccum Ait, woods, frequent.

A. canadense Kalm. Moist river banks, frequent.

Polygonatum biflorum Ell. A single plant collected along a wooded hillside.

P. giganteum Dietrich. Low open woods, infrequent,

Asparagus officinalis L. Occasionally escaped.

Smilacina racemosa Desf. Woods, common.

S. stellata Desf. Low prairies, infrequent.

Mianthemum canadense Desf. Upland woods, frequent.

Uvularia grandiflora Smith. Woods, frequent.

Oakesia sessilifolia Watson. Woods, frequent.

Erythronium albidum Nutt. Woods, common.

Lilium philadelphicum L. Low prairies, frequent.

L. canadense L. Low prairies, frequent.

Trillium erectum L. Low woods, common. The form called *T. erectum* L., var. *declinatum* Gray, occurs here and is mistaken locally for *T. recurvatum* Beck.

T. cernuum L. Low woods, infrequent.

T. nivale Riddell. Several plants were collected in 1895 by Miss Etna Burrette.

XYRIDACEÆ.

Xyris flexuosa Muhl. Low prairies, apparently rare.

COMMELINACEÆ.

Tradescantia virginica L. Low prairies, common. Flowers frequently rose-colored or nearly white.

JUNCACEÆ.

Juncus tenuis Willd. Prairies, woods and pastures, abundant.

J. nodosus L. Low, sandy ground, common.

TYPHACEÆ.

Typha latifolia L. Sloughs, common.

Sparganium eurycarpum Engelm. Swamps, infrequent.

S. simplex Huds. Swamps, infrequent.

ARACEÆ.

Arisæma triphyllum Torr. Woods, common.

A. dracontium Schott. Low woods, infrequent.

Symplocarpus fœtidus Salisb. One patch known near Wadena on wet ground. Apparently a rare Iowa plant.

Acorus calamus L. Swamps, frequent.

LEMNACEÆ.

Spirodela polyrrhiza Schleid. Ponds, abundant.

Lemna trisulca L. Ponds, infrequent.

L. minor L. Ponds, common.

ALISMACEÆ.

Alisma plantago L. Ponds, common.

Sagittaria heterophylla Pursh. Wet ground or in water, common and very variable. Mr. Cratty writes of the specimens sent him, "What a maze of forms."

S. variabilis Engelm. Wet ground or in water, probably infrequent. For the sake of uniformity I have followed Gray in synonomy here instead of Mr, Cratty's paper, Bull. Lab. of Nat. Hist., State University of Iowa 3: 136, F. 1896, though the latter doubtless offers many improvements. The same is true of all the aquatic plants.

NAIADACEÆ.

Potamogeton pennsylvanicus Cham. In water, frequent.

P. fluitans Roth. In streams, frequent.

P. mucronatus Schrad. In still water, frequent. Mr. Cratty writes, "probably this, but too imperfect for correct determina tion."

CYPERACEÆ.

Cyperus diandrus Torr. Low sandy ground, frequent.

C. diandrus Torr., var. *castaneus* Torr. With the last, probably rare.

C. aristatus Rottb. Low sandy ground, common.

C. schweinitzii Torr. Sandy ground, frequent.

C. filiculmis Vahl. Sandy soil, infrequent.

C. esculentus L. Low ground and cultivated fields, frequent.

C. strigosus L. Low, sandy ground, frequent.

Eleocharis ovata R. Br. Wet ground, infrequent.

E. palustris R. Br. Wet ground, abundant.

E. acicularis R. Br. Wet ground, abundant.

Scirpus lacustris L. Swamps, common.

S. atrovirens Muhl. Wet ground, common.

Eriophorum cyperinum L. Low ground, frequent.

E. polystachyon L. Wet ground, rare and variable.

Carex lupulina Muhl. Sloughs, frequent.

C. retrorsa Schwein. Miss Ona M. Rounds, coll. Determined by Mr. Cratty.

C. stricta Lam. Sloughs, common.

C. stricta Lam., var. *decora* Bailey. Sloughs, infrequent.

C. longirostris Torr. Low sandy ground, frequent.

C. aquatilis Wahl. Wet ground in mud or water, frequent. The plants examined were young.

C. laxiflora Lam. Some doubt as to habit, and Mr. Cratty writes that is an unusual form of the species.

C. pedunculata Muhl. Shaded bluffs, infrequent.

C. varia Muhl. Mr. Fernald says the plant was too young to be certain.

C. pennsylvanica Lam. Woods and prairies, common.

C. stipata Muhl. Wet ground, common.

C. vulpinoidea Michx. Miss Ona M. Rounds, coll. Determined by Mr. Cratty.

C. rosea Schkuhr. Woods, common.

C. interior Bailey. Bull. Torr. Bot. Club, 20: 426, N. 1883. Probably common. Probably confused formerly in Iowa as some form of *C. echinata* Murray. Not before reported from Iowa.

C. cephalophora Muhl. Mr. A. S. Skinner, coll. Determined by Mr. Cratty,

C. tribuloides Wahl. Wet ground, frequent.

C. tribuloides Wahl., var. *reducta* Bailey. Wet ground, probably frequent.

C. tribuloides Wahl, var. *bebbii* Bailey. Mr. A. S. Skinner, coll. Determined by Mr. Cratty, who also saw the other two forms of the species.

C. scoparia Schkuhr. Low ground, frequent.

C. straminea Willd. Low ground, frequent.

GRAMINEÆ.

Spartina cynosuroides Willd. Low prairies, common.

Panicum glabrum Gaudin. Waste ground, frequent.

P. sanguinale L. Cultivated and waste ground, common.

P. proliferum Lam. Waste ground, infrequent.

P. capillare L. Waste and cultivated ground, common.

P. virgatum L. Low prairies, infrequent.

P. latifolium L. Woods, frequent.

P. dichotomum L. Woods and waste ground, common.

P. crus-galli L. Waste ground, common.

Setaria glauca Beauv. Cultivated and waste ground, abundant.

S. viridis Beauv. Cultivated and waste ground, abundant.

S. italica Kunth. Frequently escaped.

Cenchrus tribuloides L. Sandy soil, common.

Leersia virginica Willd. Wet ground, frequent.

L. oryzoides Swartz. Wet ground, frequent.

Zizania aquatica L. Ponds, infrequent.

Andropogon furcatus Muhl. Prairies, common.

A. scoparius Michx. High prairies, frequent.

Chrysopogon nutans Benth. Prairies, frequent.

Phalaris arundinacea L. Wet ground, infrequent.

Stipa spartea Trin. High prairies, infrequent.

Oryzopsis melanocarpa Muhl. Rocky woods, infrequent.

Muhlenbergia glomerata Trin. Low ground, common.

M. mexicana Trin. Low ground, frequent.

M. sylvatica Gray. Woods, frequent.

M. diffusa Schreber. Woods, infrequent.

Brachyelytrum aristatum Beauv. Rocky woods, frequent.

Alopecurus geniculatus L., var. *aristulatus* Torr. Swamps, infrequent.

Sporobolus heterolepis Gray. Dry ground, frequent.

S. neglectus Nash., Bull. Torr. Bot. Club, 22: 463, N. 1896. Waste grounds and probably prairies, frequent. Not before reported in Iowa, but confused with *S. vaginæflorus* Vasey. Determined by George V. Nash.

Phleum pratense L. Commonly escaped.

Agrostis alba L. Meadows and roadsides, common.

A. alba L., var. *vulgaris* Thurb. Probably common as the last.

A. scabra Willd. Dry ground.

Cinna arundinacea L. Moist, wooded ravines, frequent.

Calamagrostis canadensis Beauv. Wet prairies, frequent.

Bouteloua hirsuta Lag. Sandy ground, rare. Mr. A. S. Skinner, Coll.

B. racemosa Lag. Dry prairies, common.

Phragmites communis Trin. Wet ground, rare.

Kœleria cristata Pers. Prairies, common.

Eragrostis reptans Nees. Sandy river banks, common.

E. major Host. Waste ground, common.

E. frankii Meyer. Sandy river banks, infrequent.

E. petinacea Gray. Sandy river banks, infrequent.

Melicca mutica Walt. Open woods, rare.

Dactylis glomerata L. Yards, rare.

Poa pratensis L. Meadows and roadsides, common

Glyceria nervata Trin. Low ground, common.

Festuca nutans Willd. Woods, frequent.

Bromus kalmii Gray. Dry ground, infrequent.

B. ciliatus L. Woods, common.

B. ciliatus L., var. *purgans* Gray. Woods, infrequent.

Agropyrum repens Beauv. Waste ground, infrequent.

Hordeum jubatum L. Waste ground common.

Elymus virginicus L. River banks, abundant.

E. canadensis L. River banks and waste ground, common.

E. striatus Willd. Woods, common.

Asprella hystrix Willd. Woods, common.

NEW OR LITTLE KNOWN PLANTS.

T. J. FITZPATRICK.

The following plants are new or little known to the flora of Iowa:

Lechea tenuifolia Mx. Van Buren county. Common in sandy soil. July.

Circæa alpina L. Clayton county. Deep woods along the Mississippi river. Rare as compared with *C. lutetiana* L. July.

Collinsia verna Nutt. Jefferson county. Frequent.

Gilia linearis Gray. Decatur county. Frequent in prairie soil. June.

Inula helenium L. Johnson county. Common locally where it has been observed for many years.

Corallorhiza odontorhiza Nutt. Reported in Natural Science Bulletin of the State University of Iowa (Vol. 3, No. 4) as new and rare. The species was very common in several localities in Johnson county during the month of August, 1896. It occurred in deep upland woods where there was a considerable depth of decaying leaves. The plants occurred singly or collected in tufts. Often only one or two were able to pierce the mat of leaves, the remainder blooming beneath. The specimens from beneath the leaves were frequently dwarfed as well as pale in appearance, though many good specimens were found in that position. This habit of growth probably prevents the specimens from being observed by the collector. The time of gathering was from the 16th to the 30th of August, which is a month later than the limit given by Gray. About 200 specimens were collected.

MECHANISM FOR SECURING CROSS FERTILIZATION IN SALVIA LANCEOLATA.

G. W. NEWTON.

This plant was found growing abundantly about Grand Island, Nebraska, especially in waste places where the sod had been removed. It is 6 to 18 inches high, has lanceolate to linear, sparsely serrate leaves. The racemes are 1 to 4 inches long. The corolla is about three-eighths of an inch long and of a delicately blue tint, the upper lip forming a pubescent hood enclosing stamens and style. The lower lip is comparatively broad, three lobed and by its protrusion affords an excellent landing place for insects. The style is nearly glabrous and is bifurcated, the upper branch being exserted and curved upwards. The lower branch is slightly flattened at the end forming the stigma, which extends a little beyond the anthers in such a position that it is quite sure to come in contact with the insects entering the flower. The stamens, two in number, are peculiar. The filaments are short and attached to the lower lip of the corolla. The anthers are long, yoke shaped, one celled at the upper ends, and are attached by hinges near the middle to the filaments. They curve backward, are united the lower third of their length and rest their lower extremities on the corolla.

There is a groove down the center of the lower lip along which the insect's proboscis will be directed in searching for nectar. By this act the sterile ends of the anthers will be raised and the anther cells will descend like the ends of an old fashioned well sweep, and come into contact with the head or proboscis of the invading insect. The pollen thus secured is quite sure to be deposited on the stigma of the next flower visited, thus securing cross fertilization. After being tilted, the anthers are under tension and readily return to their former position. A little below the middle of each anther is a slightly curved projection which fits

into a groove in the lower lip of the corolla. This mechanism may thus assist the anthers to return to their normal position, or may prevent the proboscis of the insect from being thrust down the side of the corolla, and thus evading the pollen. Many small bees were seen to visit these flowers on bright days. The plant blossoms during July and August and a few flowers were found in the latter part of September.

NOTES OF SOME INTRODUCED PLANTS OF IOWA.

L. H. PAMMEL.

Since the settlement of Iowa many changes have taken place in our flora, especially with reference to introduced plants, and the disappearance of many indigenous species owing to breaking up of prairies, and the destruction of some timber areas, and the draining of ponds and lakes.

It is with difficulty that species of *Potamogeton* have been enabled to retain their hold in water, or that *Cypripedium spectabile* should maintain itself in the wooded and much pastured timbers of Iowa. With the early settlement of Iowa there came a host of European weeds. They are so well naturalized that it is no longer possible to state whether they are introduced or indigenous, nor are we able to state when they were introduced. In fact there are no early collections, and in many cases early collectors failed to note whether the plant was introduced or indigenous. We have no early records for such common weeds as *Portulaca oleracea*, *Verbascum thapsus*, *Anthemis cotula*, *Malva rotundifolia*, *Chenopodium album*. Indeed, we are unable to say how rapidly these weeds have spread. In fact when we look over our introduced plants we find that there are but few cases in which there are statistical records such as we now have for *Lactuca scariola*, *Salsola kali*, var. *tragus* or *Solanum rostratum*, *Hieracum aurantiacum* and a few others. Those who are connected with our experiment station have frequent requests to identify weeds, and it would

seem to me proper to make a record of all such plants in a card catalogue where the specimens cannot be preserved.

It is an interesting fact to note that it frequently takes years for a weed to become so well established as to attract attention. Some years ago Dr. Halsted, while connected with the Iowa Agricultural college, noted that *Solanum rostratum* had been reported to him. This plant has long occurred in western Iowa but it is only recently that it has been reported from many parts of the state, showing increased tendency to spread. It is no longer considered worth while by the average farmer to report *Lactuca scariola*, it is so thoroughly naturalized, and yet some few years ago it was seldom seen. It has undoubtedly become thoroughly acclimated over a large extent of our territory, occurring not only in streets and timbers of our own state but in the heart of the Rocky mountains far away from any habitation.

In the appended list the species are arranged according to Gray's Manual, sixth edition, also adopting the nomenclature of that work.

RANUNCULACEÆ.

Ranunculus acris L. College campus in Ames. It is scarcely persistent.

Delphinum consolida L. Corning, 1895 (Ellen Bettonier.)

PAPAVERACEÆ.

Argemone alba L. Southern Iowa near Ottumwa.

CRUCIFERÆ.

Camelina sativa Crantz. Ames, 1891 (Hitchcock). Hazleton (Knight.)

Brassica alba Boiss. Ames. Corbett in Hitchcock. (Anthophyta and Pteridophyta of Ames, 1891, p. 486) 1896. Dooryards north of agricultural building, I. A. C. campus, Geo. Carver, 1896.

Erysimum asperum D. C. Ames, 1896, along railroads undoubtedly from the west (G. W. Carver.)

Sisymbrium altissimum L. Ames, 1895, G. W. Carver.

To this should be added the localities given by L. H. Dewey, Davenport, Blue Grass, Dickens. (Circular No. 7, Division of Bot. U. S. Dept. of Agr.

CAPPARIDACEÆ.

Cleome integrifolia Torr. & Gray. Only indigenous to western Iowa, has become a common weed in Council Bluffs, Missouri Valley, Sioux City and Onawa.

CARYOPHYLLACEÆ.

Saponaria vaccaria L. Little Rock (C. R. Ball). A weed of wheat fields.

Silene cucubalus Wibel. Ames.

Silene noctiflora L. Ames, 1896.

Lychnis vespertina Sibeth. Ames, 1896, R. Combs, C. R. Ball, Geo. Carver. Red Oak, 1896, C. G. Patten.

L. githago Lam. Rock Valley, 1896 (J. F. Jensen and W. Newell). Little Rock (C. R. Ball). Ames (Hitchcock). This weed has shifted with wheat culture. I have never seen a specimen growing in central Iowa.

MALVACEÆ.

Malva rotundifolia L. Abundant in some parts of Iowa. It is frequent in central Iowa. Common in western Iowa in cities and along the Missouri river and in eastern Iowa along the Mississippi river. Little Rock, 1893 (C. R. Ball).

Hibiscus trionum L. Ames, 1890-1896. Has scarcely escaped to fields, usually about flower gardens. Muscatine (F. Reppert). LeClaire in fields (P. H. Rolfs).

Trifolium arvense L. Collected by Professor Bessey in 1871, has not been found since.

T. agrarium L. Reported by Hitchcock from Ames in 1886, has not been found since.

T. procumbens L. Ames, 1882 (Hitchcock). Occurred in Ames in 1886. Iowa city 1884 (Hitchcock). It is now frequently collected every spring.

Melilotus officinalis Willd. As yet is not common in central Iowa though abundant in Sioux City, 1895, and Council Bluffs, 1895. Also occurs in Muscatine, 1891 (F. Reppert). Iowa City, 1889 (A. S. Hitchcock). Dakota City, 1896 (L. H. Pammel).

M. alba Lam. Iowa City, 1889 (A. S. Hitchcock). Ames, frequent, 1890 (J. F. Rolfs). (F. C. Stewart) 1891. Abundant at Moingona, 1895. Boone, 1895. Council Bluffs, 1895. Sioux City, 1895, (L. H. Pammel). Iowa City, 1887 (A. S. Hitchcock). Muscatine, 1891 (F. Reppert).

Medicago sativa L. Ames occasionally, now frequent in Council Bluffs, Muscatine, 1891 (F. Reppert). Sioux City, 1896 (L. H. Pammel).

M. lupulina L. Ames, 1871 (C. E. Bessey). Has not been found since Hitchcock (Cat. Anthenphyta and Pteridophyta of Ames, p. 491) says occasionally found in waste places.

Hosackia purshiana Benth. Indigenous loess of Iowa along the Missouri river. Sioux City. Naturalized. Boone, 1895 (G. W. Carver.)

Glycyrrhiza lepieota Nutt. Ontario, 1886 (Hitchcock). Ames (A. S. Hitchcock) 1889. Greenfield, 1891 (F. C. Stewart). Spreading at near Greenfield, undoubtedly introduced indigenous to western and northwestern Iowa. It is spreading at Hull, 1895 (W. Newell). Little Rock, 1893 (C. R. Ball). Logan, 1895. Council Bluffs, 1895. Spreading at Le Mars, 1896 (W. J. Newell). Lenox, 1896 (J. L. H.). Grand Junction, 1872 (C. E Bessey). Harrison county, 1875, Rev. Burgess.

Cassia tora L. Ames, along C. & N.-W. R. R., 1894 (C. R. Ball, Robert Combs). Not found since.

COMPOSITÆ.

Grindelia squarrosa Dunal. Indigenous to western Iowa and is rapidly spreading in contigious territory, and has been reported from Keokuk, 1891 (P. H. Rolfs). Boone and Moingona, abundant in borders of woods along C. & N.-W. R. R., 1890. Battle Creek, 1895 (E. G. Preston). Osgood, 1895, C. A. Wells. Carbonado, 1895 (John H. Smith). Smithland, 1895 (J. M. Wrapp).

Iva xanthiifolia Nutt. I have given its distribution as far as Iowa is concerned quite fully in another connection. It is, however, spreading. Reported from Keokuk 1891. Lawler, 1891 (P. H. Rolfs). Missouri Valley, 1894. Ontario, 1890. Sioux City, 1872. Ames, 1895 (G. W. Carver). Boone, 1870. Charles City, 1876 (J. C. Arthur). Woodbine, 1894. Vale, 1894. Boone, 1890 and 1894. Turin, 1894. Onawa, 1894. Carroll, 1894. Humboldt (F. L. Harvey). It will not be many years until this weed is as common in western part of Iowa as *Ambrosia trifida;* originally a plant of northern and western Iowa, from whence it has spread east and south.

Eclipta alba Hassk. Keokuk, 1877 (George E. Ehinger). 1891 (P. H. Rolfs).

Lepachys columnaris Torr. & Gray. Boone, 1889. In 1896 it was found by George W. Carver.

Helianthus annuus L. Ames and other parts in central Iowa occasional, but in western Iowa indigenous and very abundant, becoming frequent as far as Carroll, Denison and Boone. Ames, 1882. It is scarcely abundant except in a few localities in central Iowa. I am inclined to think it is an introduced plant with us. Boone, 1871 (C. E. Bessey). Grinnell, 1891 (M. E. Jones). Keokuk, 1891 (P. H. Rolfs). Muscatine, 1891 (Reppert). Marshalltown, 1891 (F. C. Stewart).

Helianthus maximiliani Schrad. Indigenous to northern and western Iowa, confined originally in western part of the state to the loess hills and adjoining bottoms, but now occurs along some of the great trunk lines extending across the state. A small patch has persisted at Ames for several years. 1894 (G. W. Carver).

Gaillardia aristata Pursh. This western plant has been found at Ames, 1896 (G. W. Carver). Too soon to say whether it will become naturalized.

Dysodia chrysanthemoides Lag. Boone, 1890. Ackley, 1878 (B. E. Canavan). Keokuk, 1891 (P. H. Rolfs). Muscatine, 1891 (F. Reppert). This striking weed has been known for some time at Ames, though said to be frequent by Hitchcock (Anth. *Pteridophyta* of Ames, p. 503). It is more or less periodic in its appearance, some years frequent, others it is not so common. It is, however, always abundant in western and southwestern Iowa, which leads me to believe that the plant is not indigenous to central Iowa, but introduced, although now occurring in timber and along river banks.

Anthemis cotula D. C. This European weed is by no means as common in dooryards, along roadsides and in streets as in Wisconsin, Illinois and Minnesota. It shows evidence, however, of being widely distributed in the state, and early introduced.

Chrysanthemum leucanthemum L. For a long period of years occasional specimens of this weed have been found in the vicinity of the college, and it is an occasional introduction in meadows, but except in one place some four miles from Ames it shows no evidence of being naturalized. It has also been reported from Muscatine (Reppert). Atlantic (S. O. Hamill). Ames, 1871 (C. E. Bessey). Ames, 1891 (P. H. Rolfs). Sheldahl, 1885 (L. V. Harpel). Ackley, 1878, (B. E. Canavan).

Tanacetum vulgare L. Although escaped here and there from gardens there are but few places where it is naturalized.

Cnicus lanceolatus Hoffm. This is a frequent weed, especially eastern, southern, northern, western and central portions of the

state, and found as an occasional plant in every part of the state, especially in pastures where timber has been cut. It shows evidence of having been introduced a long time. Boone, 1890. Lawler, 1890. Keokuk, 1891 (P. H. Rolfs). Muscatine, 1891 (F. Reppert). Iowa City (A. S. Hitchcock).

C. altissimus Willd., var. *filipendulus* Gray. Indigenous in Western Iowa, loess hills, is spreading to cultivated fields eastward. Reported from Ruthven (Daniel Chaffie). Atlantic, 1895. Marcus, 1895 (N. E. Willey).

C. arvensis Hoffm. Widely distributed in the state, but generally confined to small areas. It is reported more frequently than any other *Cnicus*, though the least common of our species, it is interesting to record the fact that occasionally seed is produced. Lawler, 1890 (P. H. Rolfs). Greenfield, 1891 (F. C. Stewart). Marcus, 1896 (Willey). Winterset, 1896. Corning, 1895 (A. B. Shaw). 1896 (Chas. B. Collman). Chase, Johnson county, 1874 (O. G. Babcock). Taylor, 1895 (J. B. Matthews). Maple River Junction, 1895 (L. Bernholtz). Farragut, 1895 (C. Collman). Randall (C. and G. P. Christianson). Redding (Dr. W. A. McClanahan). Griswold (R. E. Pierce). Conrad Grove, Cresco, 1892, with "seed" (C. V. Johnson). Oelwein (J. Thompson). Chickasaw county (P. H. Rolfs). Muscatine (F. Reppert). Barnes City, 1896 (J. W. Jones).

Cichorium intybus L. Corning, 1895 (Ellen Bettonier). Midway, well established, 1896. Des Moines, 1895.

Tragopogon porrifolius L. Ames, 1896 (C. R. Ball).

T. pratensis L. Ames, in meadow, 1894. Iowa City, 1889, Newton, 1889 (A. S. Hitchcock).

Hieracium aurantiacum L. Ames, 1894, meadows, not established.

Lygodesmia juncea Don. Indigenous only to western and northwestern part of the state, becoming a bad weed in northwestern Iowa. (C. R. Ball.) Armstrong (R. I. Cratty). Most abundant on loess hills; has appeared at Carroll, 1895, Logan, and other points along the C. & N.-W. R. R.

Lactuca scariola L. Abundant everywhere in Iowa except northwestern and possibly northeastern. Marshalltown, 1891 (F. C. Stewart). Ames, 1889 (A. S. Hitchcock). Muscatine, 1891 (F. Reppert).

L. pulchella D C. Indigenous to loess hills of western Iowa. Has become abundant along roadsides and streets in Sioux City. Showing tendency to spread. Ames, 1887, 1889 (A. S.

Hitchcock). Fremont county (A. S. Hitchcock). Sioux City, Council Bluffs, Keokuk, 1891 (P. H. Rolfs).

BORRAGINACEÆ.

Echium vulgare L. Ames, 1894 (G. W. Carver). Not since observed.

CONVOLVULACEÆ.

Convolvulus arvensis. Ames. Since 1887 well established. Ladora, 1895 (John Hiltbrummer). Des Moines, 1896 (C. N. Page). Very likely occurs in other places. First introduced as a cultivated plant. This may become one of our most pestiferous of perennial weeds.

SOLANACEÆ.

Solanum carolinese L. This weed has been well established on the college farm since 1887. As it started in an experimental plot, I am inclined to think it was introduced accidentally with some cultivated plants. It has been reported to me from many other places in the state. Certainly showing an extension northward and that acclimation has occurred.

The following are the localities for this state:

Zearing, 1896 (J. S. Bartley). Indianola, 1895 (A. D. Field). Mapleton, 1895 (Abjh. Lamb). Story City (C. C. Johnson). Central City, 1894 (Herman Finson). Fayette, 1894 (Mrs. M. E. Williams). Logan, 1895, Council Bluffs, 1895. (L. H. P.) Professor Bessey informs me that he observed it here many years ago. It is well established at this point. Ogden, 1894 (John Williams). Plattsville, 1894 (J. B. Studley). Des Moines, 1894. Woodbine (Erastus Childs, Geo. Phillips). Muscatine (F. Reppert). Keokuk, 1891 (P. H. Rolfs). Taylor county, 1894 (C. O. Pool). Grand Junction, 1890.

Solanum rostratum Dunal. This weed has been reported from many widely scattered localities. It was not common in 1887 or up to 1890, since Professor Hitchcock, a diligent collector, does not report it in catalogue of the Anthophyta and Pteridophyta of Ames, Iowa, 1891. It has been long known in western Iowa, as Professor Todd informs me. Ames, 1895 (John Arrasmith, Turner McClain). Montezuma, 1895 (J. M. Bryan). Aspinwall, 1895 (C. H. Laughlin). Woodbine, 1895 (R. B. Boustead). New Hartford, 1895 (J. W. P). Maple Grove, 1895 (Mitchell). Gilmore City, 1895 (Van Alstine). Rowley, 1895 (J. G. E. McDonald). Creston, 1895 (Mrs. Mary A. McClure). I observed it common in the streets at this place in

1894. Newell 1894, Corning, 1894, Ainsworth, 1894, Perlee, 1894 (D. M. Carty). Ladora, 1896 (Whitlocker and Fields). Emmetsburg, 1896 (McCarty and Lindermann). New London, 1895. Guthrie Center (W. M. Ashton). Whitmore, 1894 (J. E. Albin). Morrison, 1894 (A. E. Allen). Elliott, 1895 (Adam Lentz). Renwick, 1895 (Bell and Thiel). Dysart (Emma Sirrine). Des Moines, Carson (J. A. Bass). Perry, 1895 (Geo. O. Roberts). Gilmore City, 1895 (D. Van Alstine). Hamburg, 1888 (A. S. Hitchcock). Agency, 1887 (Mrs. Richman). Council Bluffs, 1883. Mt. Ayr, 1894 (J. W. Sale). Carroll county, Des Moines fair grounds (A. G. Lucas).

Solanum Torreyi Gray. Southern Iowa, 1895.

SCROPHULARIACEÆ.

Verbascum Thapsus L. This weed is common in eastern, central and southern Iowa. Probably early introduced. It is not, however, spreading rapidly.

V. Blattaria L. Ames, 1889 (Hitchcock). And several times since (F. A. Sirrine). Not, however, a permanent weed. Muscatine, 1890 (F. Reppert).

Linaria, vulgaris Mill. Ames. I am unable to learn when first introduced. Well established.

LABIATÆ.

Salvia lanceolata Willd. Indigenous to western Iowa. Council Bluffs, Fremont county, Missouri Valley, Ames, 1890 (F. A. Sirrine). Des Moines, 1895. Well established. Muscatine, 1890 (F. Reppert).

PLANTAGINACEÆ.

Plantago lanceolata L. Ames, 1874 (C. E. Peterson). Well established in fields. Milton (J. C. Holland).

CHENOPODIACEÆ

Cycloloma platyphpyllum Moquin. Not indigenous in Iowa. Cedar Rapids, Des Moines, 1894 (G. W. Carver). Muscatine, 1890. Des Moines, 1887 (A. S. Hitchcock). Hamburg (A. S. Hitchcock).

Chenopodium urbicum L. Nevada, 1880 (A. S. Hitchcock). Iowa City 1887 (A. S. Hitchcock). Keokuk, 1887 (A. S. Hitchcock). Ames, 1891 (A. S. Hitchcock). Muscatine, 1889, Davenport, 1889 (A. S. Hitchcock). Muscatine, 1890 (F. Reppert). Keokuk, 1891 (P. H. Rolfs).

C. glaucum L. Iowa City, 1889 (Hitchcock). Muscatine (F. Reppert).

C. Botrys L. Ames, 1883; Iowa City, 1887 (A. S. Hitchcock).

C. ambrosioides L. Keokuk (J. C. Arthur). Muscatine, 1876 (Burgess.) Muscatine 1890 (F. Reppert).

C. Rubrum. Keokuk, P. H. Rolfs, 1891.

Atriplex patulum L., var. *hastatum* Gray. Keokuk, 1891 (P. H. Rolfs). Ames, 1896-6. It has become well established. Iowa City, 1887 (A. S. Hitchcock). Var. *littorale.* Iowa City, 1887 (A. S. Hitchcock).

A. argenteum Nutt. Ames, 1895 G. W. Carver).

PHYTOLACCACEÆ.

Phytolacca decandra L. Grinnell, 1889 (A. S. Hitchcock). Muscatine, 1891 (F. Reppert).

POLYGONACEÆ.

Rumex Patieutia L. Boone (G. W. Carver). Established. Escaped from cultivation.

Polygonum orientale L. Muscatine, 1890 (F. Reppert). Onawa, 1894.

EUPHORBIACEÆ.

Euphorbia marginata Push. Indigenous to western Iowa. Little Rock, Sioux City, Onawa, Council Bluffs and Hawarden. Naturalized east. At Denisôn abundant, 1894. Woodbine, 1894. Vale, abundant, 1894. Missouri Valley, Carroll, 1895, abundant (W. Newell). Hamburg, 1888 (A. S. Hitchcock). Iowa City, 1887 (A. S. Hitchcock).

A STUDY OF THE LEAF ANATOMY OF SOME SPECIES OF THE GENUS BROMUS.

EMMA SIRRINE.

The species of genus Bromus are sometimes difficult to differentiate; hence, a study of the leaf anatomy was undertaken with a view towards a help in differentiation.

BROMUS ASPERT.*

(Pl. v. Fig. 5; Pl. vii, Fig. 8.)

Epidermis.—The cuticle in this species is quite thick. The epidermal cells are large, but are smaller and thicker walled above and beneath the primary mestome bundles than elsewhere. Stomata frequently occur on both surfaces. The upper and lower surfaces of leaf, as well as edges, are provided with trichomes, sometimes in the form of small conical projections.

Bulliform cells.—These occur on superior surface, and vary in number from three to five, and are not as thick walled as the epidermal cells. They occur between the mestome bundles, but this arrangement is not uniform, that is, they are not present between all mestome bundles.

Mestome bundles.—Twenty-nine mestome bundles occur across middle portion of leaf. The bundles are of three types: First, the primary type numbers eleven bundles. These open on both superior and inferior surfaces of leaf, *i. e.*, the leptome and hadrome are in direct contact with the stereome or separated from it only by colorless parenchyma cells; they vary in size (from the midrib to the margins of leaf); the one of the midrib is the largest. Bundles of the secondary type number seventeen. These are entirely closed, *i. e.*, chlorophyll bearing

*This was determined later as Bromus patulus. M. & K., by F. Lamson-Scribner.

There is an apparent repetition in papers by Miss Sirrine and Miss Pammel, in fact the same species were studied. They appeared distinct, but Professor Lamson-Scribner determined them as above. L. H. PAMMEL.

parenchyma enclose the leptome and hadrome. They alternate with the primary bundles, except at the margins of the leaf, when three occur in succession on one side of the large primary bundle in the carene. Two of the secondary bundles are present; on the opposite side of the primary bundle in the carene, a bundle occurs which is intermediate between the primary and secondary bundles; this intermediate bundle is open inferiorly only, *i. e.*, the leptome only is in contact with the stereome. This is the only bundle of this type found in this species, but it was constant in all the *asper* sections examined. The primary bundles are enclosed by thick-walled cells, the mestome sheath; outside of this is a row of thinner-walled cells, the parenchyma sheath. In the bundles of the secondary and intermediate types, the mestome sheath occurs, while the parenchyma sheath disappears.

Carene.—The carene consists of only one bundle, which is the primary type; this conforms to the description given to others of this kind, except that it is the largest bundle. The hadrome is separated from the sterome by colorless parenchyma cells, while a single row of thick walled sells, resembling stereome, separates the leptome from the hadrome. Two large pitted ducts and two spiral ducts with an intercellular space are present. The bundle is enclosed by mestome and parenchyma sheaths. Trichomes in the shape of conical projections occur on the inferior surface of leaf above the primary mestome bundle. To one side of this a secondary bundle occurs, with pitted and spiral ducts. On the opposite side of the primary bundle the intermediate bundle occurs. This is open inferiorly only. The leptome is in contact with the stereome by means of two rows of colorless parenchyma cells, while the mestome sheath surrounds the mesophyll. In other respects it is the same as the secondary bundle.

Stereome.—Stereome occurs both on superior and inferior surfaces of the primary bundles. None is present in the bundles of the secondary type and only a very little on the inferior side of the intermediate bundle. Stereome occurs in groups of from four to six cells on the margins of the leaf. The walls of the stereome are frequently stratified.

Colorless parenchyma is found beneath all the primary bundles; it fills the space between the hadrome and the stereome, while a single row of cells enclose the whole mestome bundles. In the bundles of the secondary type it disappears entirely.

Mesophyll.—This surrounds the bundles of the secondary type and occurs between all bundles. It is made up of irregular cells, but quite uniform in size. The chlorophyll granules are quite large and numerous.

BROMUS PATULUS, M. & K.

(Pl. v., Fig. 3; Pl. vi. Fig. 6.)

This is a small early form determined as *B. nivilis*.

Epidermis.—The epidermal cells of this species are large, regular, thick-walled with a strong, well developed cuticle; the cells above and beneath the carene are smaller and thicker than elsewhere; the leaf is more involute than that of any other species studied, unless possibly *Bromus racemosus*. Trichomes are numerous,—some very long and slender, others are short and thick. Stomata occur on both surfaces of the leaf.

Bulliform cells.—The bulliform cells vary in number from three to five, and are not as apparent as in some of the other species studied. These cells occur on superior surface of leaf between the mestome bundles.

Mestome bundles.—These number from twenty-five to thirty and are of two kinds. The bundles of the primary type number from nine to eleven, represented by the principal bundle of the carene. This is open both to the upper and lower surfaces of the leaf, *i. e.*, the leptome is in direct contact with the stereome, while the hadrome is separated from it only by colorless parenchyma cells. The secondary bundles number from sixteen to eighteen. The leptome and hadrome are entirely surrounded by chlorophyll-bearing parenchyma. In the largest bundle of the primary type the stereome is very abundant, while in the smaller ones, it is reduced in some instances to a single row of cells; the leptome and hadrome are well developed in these bundles and they are separated from each other by thick-walled cells resembling stereome. Both spiral and pitted ducts, as well as the intercellular space, are well defined. The secondary bundles are surrounded by colorless parenchyma without stereome. The leptome and hadrome are differentiated. Two secondary bundles occur on margins of leaf.

Carene.—The carene consists of one typical primary bundle with leptome and hadrome well developed and separated from each other by thick-walled parenchyma cells; the pitted and spiral ducts are well developed and also the intercellular space is conspicuous. On one side of this bundle is another primary

bundle, smaller than the mid-bundle but open superiorly and inferiorly, *i. e.*, the leptome and hadrome are in contact with the stereome, but this bundle differs from the first described, in that it has inferiorly only a single row of stereome running from the bundle to the epidermal cells, while in the first one there is a large amount of stereome on inferior surface. The stereome beneath this second bundle conforms with that found in the other primary bundles of this species. All these primary bundles are surrounded by two sheaths: an outer, thin-walled colorless row of cells, the parenchyma sheath and inside this a thick-walled row of cells, sometimes incomplete, the mestome sheath. The bundle on the other side of the central bundle is one of the secondary type. No stereome occurs in connection with these bundles; they are entirely closed, that is, wholly surrounded by chlorophyll-bearing parenchyma. These bundles are enclosed by a mestome sheath but the parenchyma sheath is absent. The leptome and hadrome fill the entire space inside the mestome sheath unless possibly a few thick-walled cells between them.

Stereome.—This occurs only above and below the primary bundles, and on the margins of the leaf.

Colorless parenchyma occurs below the stereome of all primary bundles, and forms a sheath for the whole primary mestome bundle.

Mesophyll.—This surrounds not only the secondary bundles but occurs between all the primary and secondary bundles.

BROMUS INERMIS.

(Pl. v, Fig. 4; Pl. vii, Fig. 10.)

Epidermis.—In this species we find large, regular, and well developed epidermal cells with a thick cuticle; the cells are smaller and the cuticle thicker under and above the mestome bundles than elsewhere. The epidermal cells are slightly longer on superior surface of leaf than on inferior surface. Trichomes absent. Stomata occur on both surfaces of leaf, but especially between the bulliform cells.

Bulliform cells.—These are large, varying in number from three to seven, only present on superior surface of the leaf.

Mestome bundles.—These number thirty-five, and are of three types, as in some specimens of *Bromus asper*. First, those of the primary type; these are open both on anterior and inferior surfaces of the leaf, *i. e.*, the leptome is in direct contact with the stereome and the hadrome, separated from it only by

colorless parenchyma cells. These primary bundles are enclosed by the parenchyma and mestome sheaths. Those of the secondary type are entirely closed and surrounded by chlorophyll-bearing parenchyma. Third is an intermediate type, open only inferiorly; the leptome is in contact with the stereome, while the hadrome is surrounded by chlorophyll-bearing parenchyma cells. These intermediate bundles occur in only two places in the leaf,—one is found in the carene and one at the margin of the leaf.

Carene.—The carene consists of one mestome bundle. A large bundle open above and below, *i. e.*, the leptome and hadrome are in contact with the stereome. The pitted ducts are irregular. The stereome is more abundant above than below the bundle. This is true of all the open bundles in this species; the leptome is separated from the hadrome by a layer of thick-walled parenchyma cells, while the whole bundle is enclosed in both parenchyma and mestome sheaths. On one side of this primary bundle a secondary bundle occurs; this is entirely closed by chlorophyll-bearing parenchyma cells. Leptome and hadrome are present with a few thick-walled cells between them, and the whole enclosed by a mestome sheath. On the opposite side of the primary bundles is one of the intermediate type.

Stereome.—This occurs on the margin of leaf above and below the primary bundles, and above the intermediate bundles.

Colorless parenchyma is more or less developed below all the bundles of the primary type.

Mesophyll is found between all bundles, surrounding the secondary and below the intermediate bundles. It consists of elongated cells filled with chlorophyll.

BROMUS SECALINUS.

(Pl. vi, Fig. 2; Pl. viii, Fig. 9.)

Epidermis.—In this species, the epidermal cells are large and regular on inferior surface with an occasional cell projecting outwardly. On the superior surface of the leaf the cells are somewhat smaller and of same general shape. The leaf is somewhat involute. Small trichomes in the shape of conical projections are present on the inferior surface of the mestome bundles. Epidermal cells are smaller where it covers the primary mestome bundles in this species, as in all studied. Stomata present on both surfaces.

Bulliform cells.—These occur only on superior surface of leaf and vary in number from three to seven. These cells are large and well marked, especially the central cells of the group; the outer are smaller and blend with the epidermal cells. The cuticle is not so strongly developed over the bulliform cells as elsewhere.

Mestome bundles.—These number from thirty-three to thirty-five and are of three types. First, primary, in which superior and inferior surfaces of leaf are open, *i. e.*, the leptome is in direct contact with the stereome and the hadrome separated from it only by the uncolored parenchyma cells. From thirteen to fifteen of these bundles are present, varying in size from the carene to the tip of leaf. In the secondary type, leptome and hadrome are entirely surrounded by chlorophyll parenchyma. The bundles in this type number from fifteen to seventeen; they alternate regularly with those of the primary type except between the sixth or seventh primary bundles counting from the mid-rib where two of the secondary type occur in succession. Only two bundles of the intermediate type occur. These are found near the margins of the leaf. They have leptome in contact with stereome only. Surrounding all the bundles occur both parenchyma and mestome sheaths.

Carene.—Only one bundle present in the carene. It is of the first type and is remarkable for the large amount of stereome on the superior surface of leaf. The leptome and hadrome are separated from each other by two rows of thick-walled parenchyma cells. The leptome is separated from stereome only by the parenchyma and mestome sheaths, while the hadrome is separated from the stereome by a large number of colorless parenchyma cells. On either side of the carene, the small secondary bundles occur. In these the leptome and hadrome seem to be in direct contact with each other. Both sheaths are present.

Stereome.—No stereome occurs around the secondary bundles. It is abundant on superior and inferior surfaces of the primary type and on superior surface of the intermediate bundles. A group of these cells also on margins of leaf. Stereome cells are marked with small canals.

Colorless parenchyma.—This occurs beneath all primary bundles, while a sheath encloses all the bundles.

Mesophyll.—This surrounds all the secondary bundles and occurs between the other two types, and on inferior portion of the intermediate type.

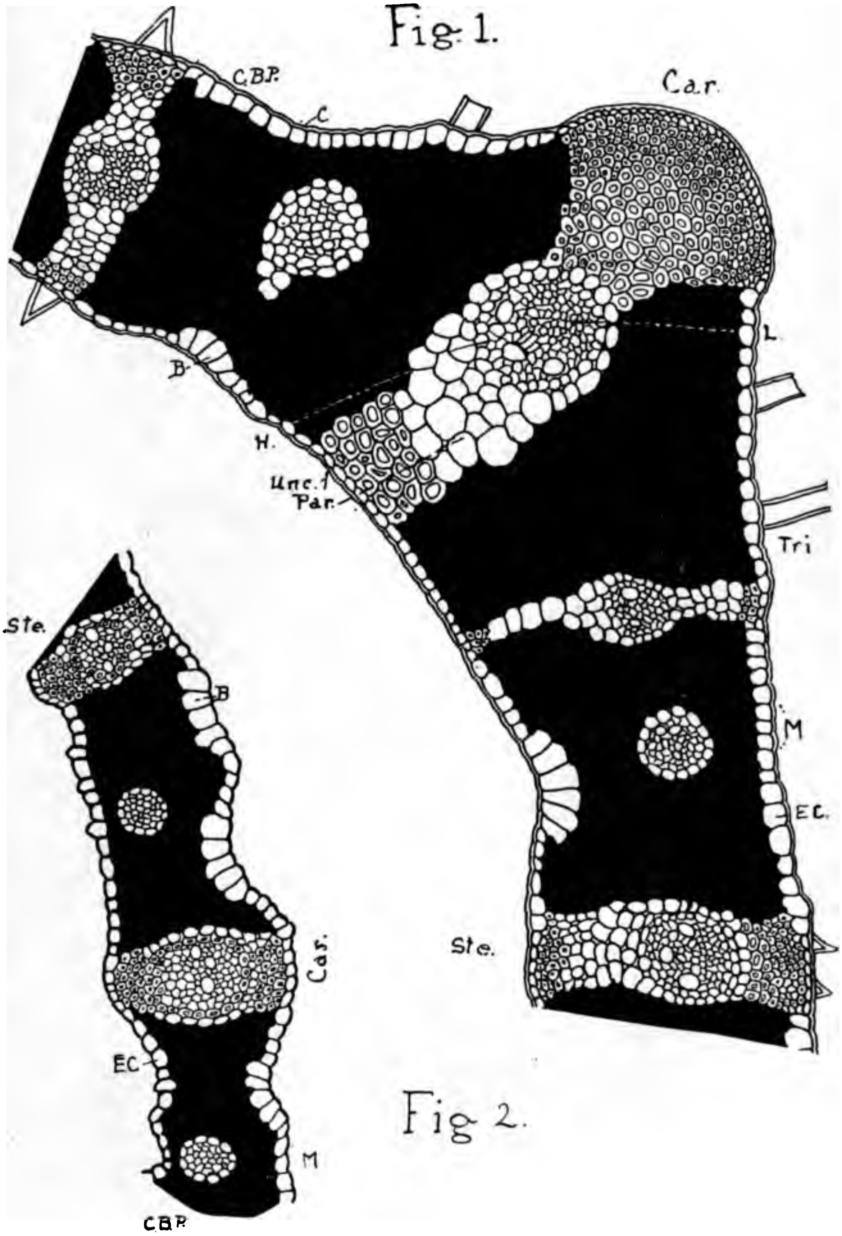


Fig. 1.
C.B.P.
Car.
C
L
B
H.
Unc.
Par.
Tri
Ste.
B
M
EC.
Car.
Ste.
EC
M
C.B.P.
Fig 2.

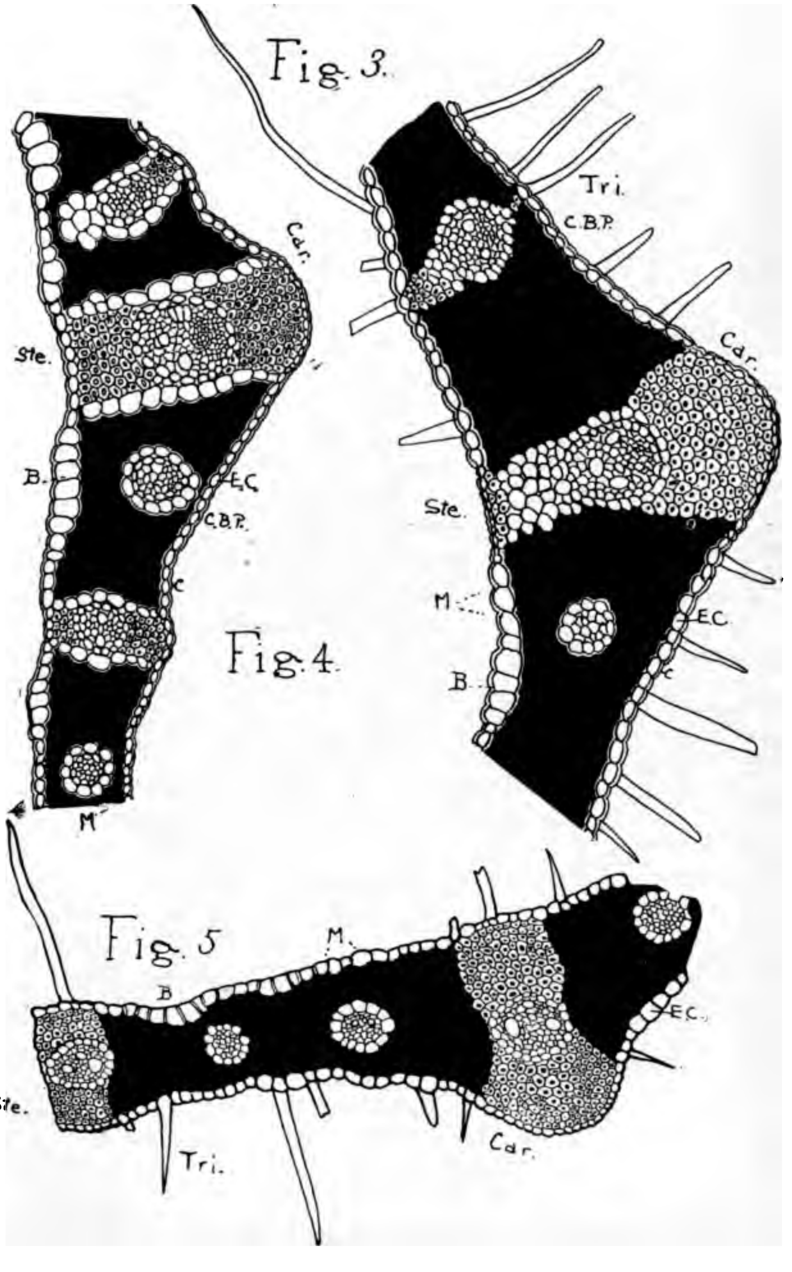
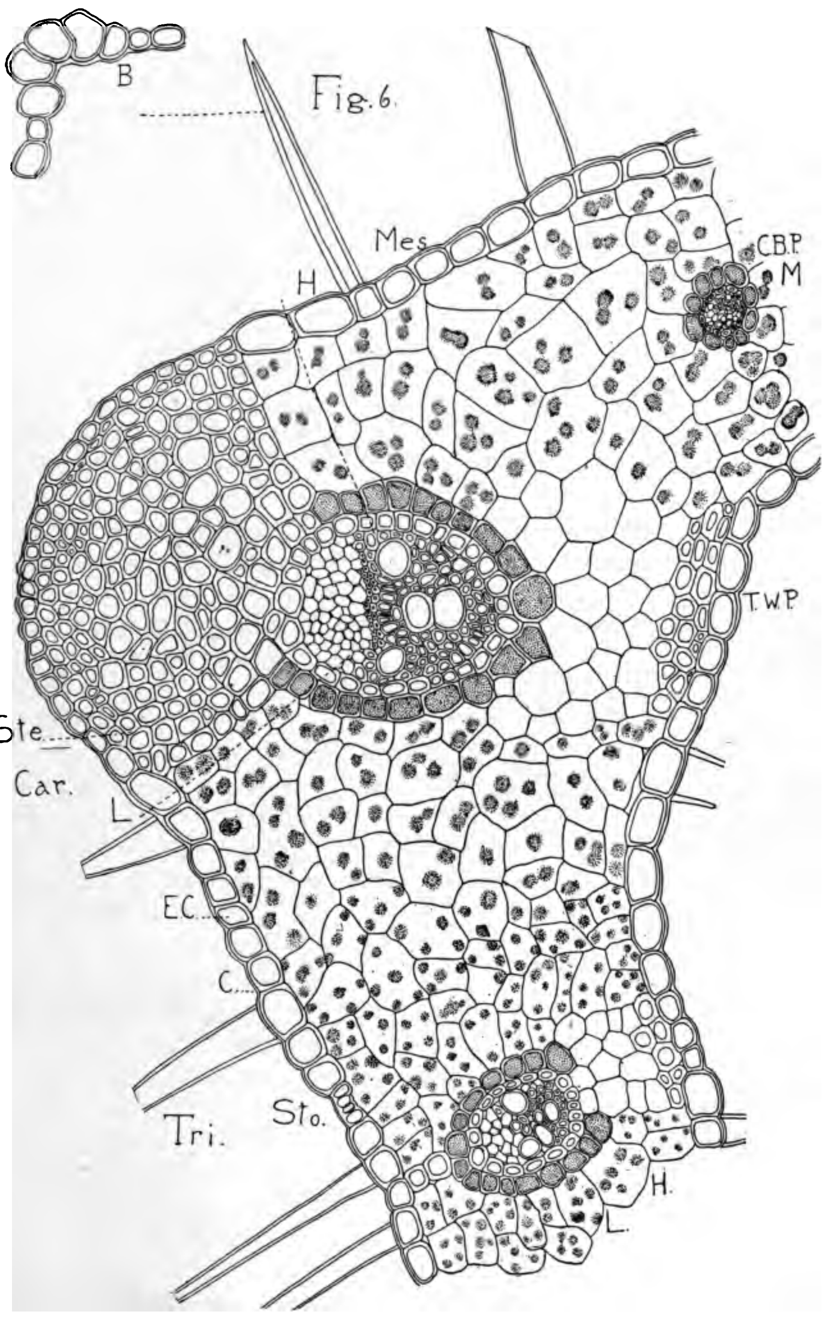
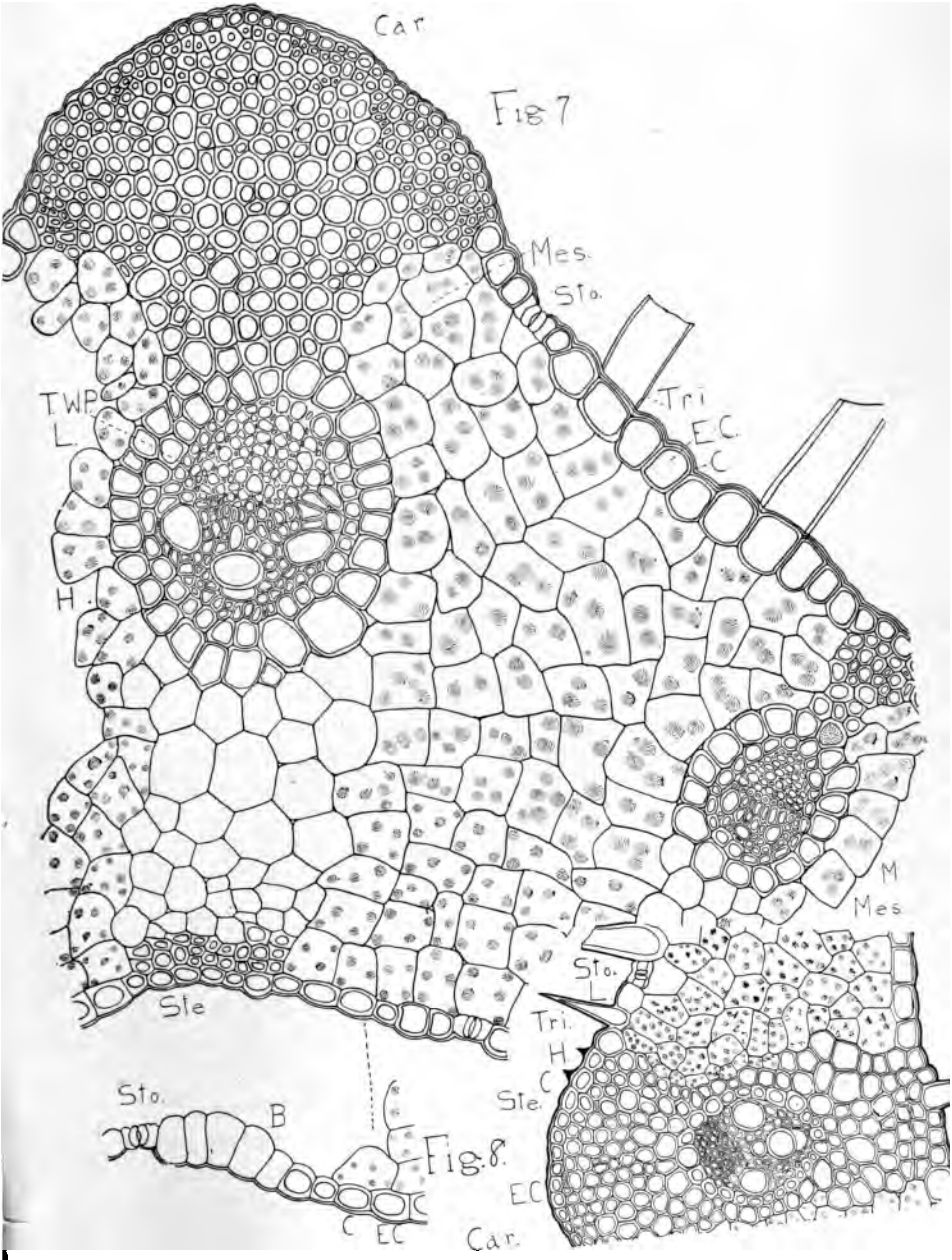


Fig. 3.
Tri.
C.B.P.
Car.
Ste.
M
E.C.
B.
c
Fig. 4.
Car.
Ste.
B.
E.C.
C.B.P.
c
M
Fig. 5
M.
B
E.C.
Ste.
Tri.
Car.


B
Fig. 6.
Mes
H
C.B.P.
M
T.W.P.
Ste
Car.
L
E.C.
C
Tri.
Sto.
H.
L.


Car.
Fig. 7
Mes.
Sto.
Tri.
E.C.
C.
T.W.P.
L.
H.
M.
Mes.
Sto.
L.
Tri.
H.
C.
Ste.
EC.
Car.
Ste.
Sto.
B
Fig. 8.
C
EC

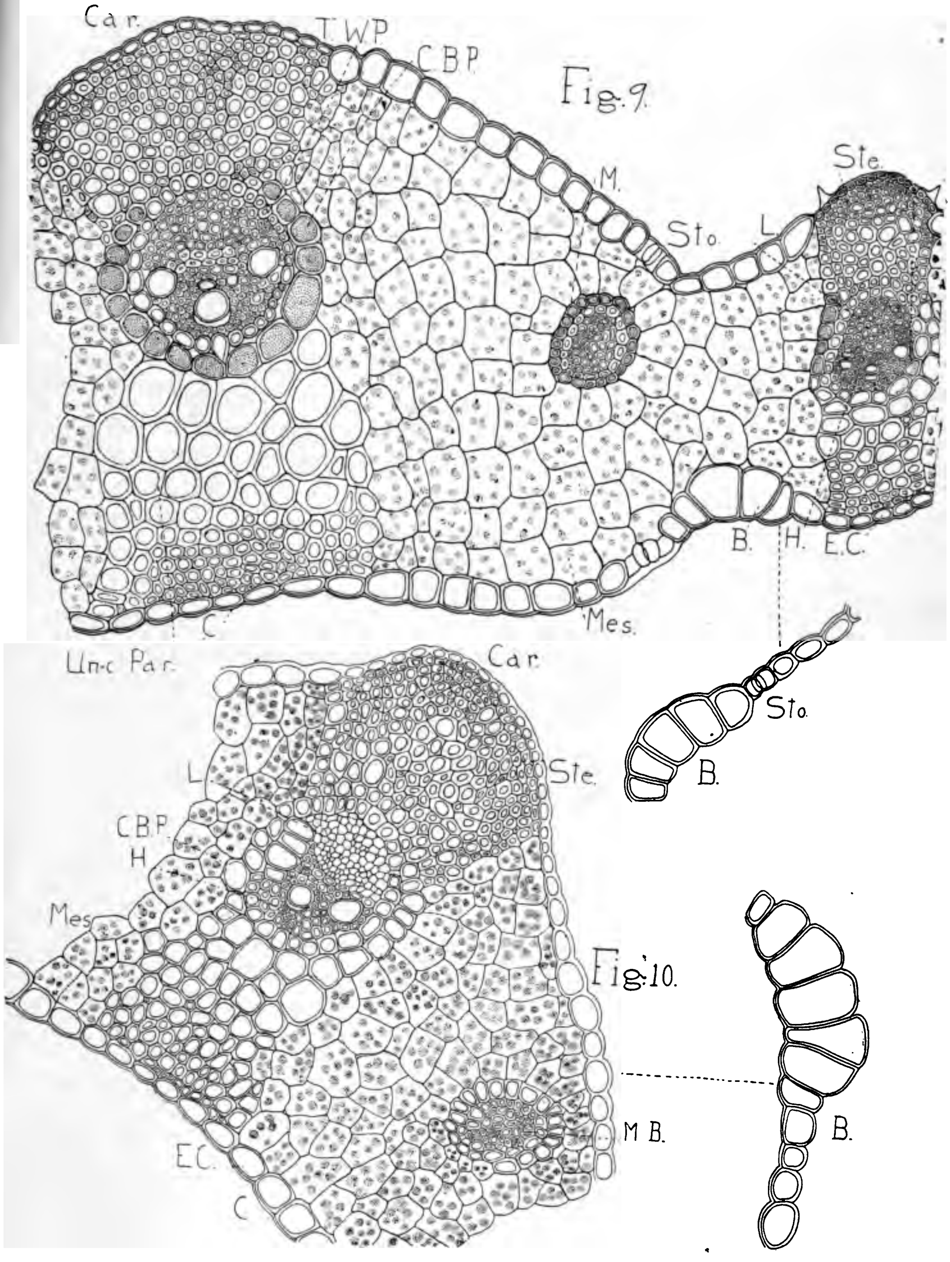


Fig. 9.
Car.
T.W.P.
C.B.P.
M.
Sto.
L.
Ste.
B.
H.
E.C.
Mes.
C.
Un-c Par.
Sto.
B.
Fig. 10.
Car.
Ste.
L.
C.B.P.
H.
Mes.
E.C.
C.
M B.
B.

BROMUS BREVIARISTATUS.

(Pl. iv, Fig. 1; Pl. vii, Fig. 7.)

Epidermis.—The epidermal cells are large and nearly rectangular, with a thick cuticle. The cells are a trifle smaller on inferior surface of leaf than on anterior, while on superior and inferior surfaces of mestome bundles they are much smaller than elsewhere. Conical projections occur both anteriorly and inferiorly on primary mestome bundles. Stomata are present on both surfaces, while trichomes are long and quite abundant.

Bulliform cells.—The bulliform cells are large and vary in number from three to six.

Mestome bundles.—Forty-one bundles present, of two types. Those of the primary type are open on both inferior and superior surfaces, *i. e.*, leptome is in direct contact with stereome, while hadrome is separated from it only by colorless parenchyma. These primary bundles vary much in size, and also in the amount of stereome and colorless parenchyma. The secondary bundles are somewhat better developed in this species than in other species studied, in that both mestome and parenchyma sheaths are present, also spiral and pitted ducts. There is an indication of an intermediate bundle at the margin of the leaf.

Carene.—Carene consists of only one bundle, and with the exception of size, the large amount of stereome and colorless parenchyma is exactly the same as those in the other species.

Colorless parenchyma.—The colorless parenchyma occurs beneath all primary bundles, while a sheath encloses all the bundles.

Stereome.—This is abundant on both inferior and superior surfaces of the primary type of bundles and on superior surface of the intermediate bundles.

Mesophyll.—This surrounds all the secondary bundles and occurs between the other two types, and on the inferior portion of the intermediate type.

EXPLANATION OF PLATES.

All drawings made with a camera and drawn to the same scale. The abbreviations used are: C., cuticle; E., epidermis; E. C., epidermal cells; Sto., stomata; Tr., trichomes; B. C., bulliform cells; Ste., stereome; Mes., mesophyll; C. B. P., chlorophyll-bearing parenchyma; Car., carene: M. B., mestome bundles; H., hadrome; L., leptome; Unc. Par., uncolored parenchyma; T. W. P., thick-walled parenchyma.

PLATE iv, Fig. 1, Bromus breviaristatus. Fig. 2, Bromus secalinus.

PLATE v., Fig. 3., Bromus patulus. Fig. 4, Bromus inermis. Fig. 5, Bromus asper.

PLATE vi, Fig. 6, Bromus patulus.

PLATE vii, Fig. 7, Bromus breviaristatus. Fig. 8, Bromus asper.

PLATE viii, Fig. 9, Bromus secalinus. Fig. 10, Bromus inermis.

A COMPARATIVE STUDY OF THE LEAVES OF LOLIUM, FESTUCA, AND BROMUS.

BY EMMA PAMMEL.

There are some striking differences in the leaves of Festuca and Lolium. One of the most essential in the species studied is the presence or absence of hairs and the involute character of the leaf of *Festuca tenella.*

LOLIUM PERENNE.

(Pl. ix, Fig. 3; Pl. xi, Fig. 8.)

Epidermis.—The cuticle is quite strongly developed on superior and inferior surfaces of the leaf, but more so on the inferior surface. The epidermal cells are rather large, but vary some in size; the largest occur on inferior surface of leaf and are nearly as large as the bulliform cells. The smallest epidermal cells occur chiefly at the tip of leaf. The epidermal cells above and below the stereome are smaller and are strongly thickened.

Bulliform cells.— The conspicuous bulliform cells number from four to five. The central are large and one or two on either side occur between each mestome bundle. The epidermal cells on the inferior surface of leaf are more uniform in size.

Mestome bundles.—These number eighteen, of three types. Primary bundles, those which are open on superior side of leaf, *i. e.*, where hadrome is either in direct contact with stereome or separated from it by colorless parenchyma cells, and secondary bundles or such as are closed, *i. e.*, the leptome and hadrome entirely surrounded by chlorophyll-bearing parenchyma; and third the intermediate type. The secondary mestome bundles are more numerous. The leptome and hadrome of the mestome bundle of carene are well developed. The mestome bundle of carene is of the primary type with well developed pitted vessels and spiral ducts. Two rows of thick-walled cells separate hadrome and leptome. The hadrome is separated from the

stereome by several rows of thin-walled parenchyma cells. The stereome is more strongly developed on the inferior surface of mestome bundles of carene than than on superior surface of bundle. In carene the stereome is not in contact with leptome.

A thin-walled parenchyma sheath surrounds the entire bundles of secondary type. Thick-walled cells occur on the inside of this parenchyma sheath, which thus forms a sheath around the leptome and hadrome.

Two kinds of mestome bundles of secondary type occur, one in which leptome and hadrome are perfectly developed, and a second in which leptome and hadrome are not so strongly marked. Those of the second type alternate with the large bundles. These bundles are surrounded by a chlorophyll-bearing parenchyma sheath. To the inside of this sheath is a second sheath which consists of thick-walled cells (mestome sheath) surrounding the leptome and hadrome, and hence is closed. The mestome bundles of intermediate type are four in number, and do not vary from the mestome bundle of primary type except that they are closed, and there are only two pitted vessels.

Stereome.—The stereome is found on margin of leaf on superior surface of all bundles of intermediate and primary types, and on the inferior surface of some of the mestome bundles of secondary type.

Mesophyll.—This occurs between the mestome bundles, and is in contact with the epidermis on both faces. The cells are irregular, some are nearly round, others are oblong. The chlorophyll grains are large. The cells of the mesophyll on margins of leaf are somewhat smaller than in other parts.

FESTUCA.

Two species of *Festuca* were studied. *Festuca elatior*, variety *pratensis*, and *Festuca tenella.*

Beal quotes Hackel's statement as to the different forms of Festuca: "Hackel finds the mesophyll and fibro vascular bundles quite uniform with all sorts of treatment of the plants, but the epidermis offers remarkable differences, especially that on lower surface of leaf. This difference is apparent in the thickness of the outer walls, the size of the cavities, and the existence or absence of projections on the partition walls. The dry cultivated plants had their epidermis strongly thickened toward the outside, the cavities diminished and over the partition wall

had developed cuticular projections. The moist cultivated plants produced slightly thickened epidermal cells, broad cavities, and no trace of cuticular projections. The sclerenchyma, or bast, varies much with different soils and amounts of moisture. Species of moist, shady habitats, show in their leaves a clear preponderance of the assimilating over the mechanical system."

These views coincide with the observation made in a study of the species here considered.

FESTUCA ELATIOR, VAR. PRATENSIS.

(Pl. ix, Fig. 1; Pl. xi, Fig. 9.)

Epidermis.—The epidermis is quite strongly developed in this species; the cuticle is more strongly developed on the inferior than superior surface. Small conical projections occur only on the superior surface of leaf. These are not very numerous. They are most numerous near the carene. The epidermal cells are quite uniform in shape; some variations occur, mostly on the superior surface. The cells of epidermis over the stereome on both superior and inferior surfaces are strongly thickened and are smaller than the unthickened epidermal cells.

Bulliform cells.—The bulliform cells are similar in size to those found in *Lolium perenne.* They are five in number, three large cells in center and one smaller one on either side. These are much more strongly developed toward the middle of leaf than on the margin. On approaching the margin of the leaf the bulliform cells can hardly be distinguished from ordinary epidermal cells.

Mestome bundles.—The number of mestome bundles in a single cross section in middle of leaf *is* twenty-four, and are not so close as in *Lolium.* There are three types. First, primary type, open on inferior and superior sides. Secondary type, those that are entirely closed, and these are most numerous. Third, the intermediate type, which are open only on superior side. The bundles of secondary type are most numerous. Three of the closed bundles occur near the margin of leaf. One bundle of the primary type is found next to the closed bundles. The third type is found to the left of mestome bundle of carene, and to the right of carene is found a mestome bundle of second type. One primary mestome bundle occurs in carene.

In the carene leptome and hadrome are well developed. The pitted vessels are large. Stereome is well developed on inferior

and superior surfaces of the bundle. In the carene, leptome and hadrome are separated from each other by thick-walled cells. The cells in leptome are somewhat more thick-walled than in hadrome.

In some of the mestome bundles of third type the hadrome is not so well developed; the intercellular space is not evident. This is not the case with mestome bundles of first type, in which this space is very conspicuous. The leptome is in direct contact with stereome, but hadrome is separated by thin-walled parenchyma cells. The bundles of second type are small; leptome and hadrome are but slightly developed, most of the bundles containing only thick-walled cells, while occasionally there is a bundle which has an indication of one or two pitted vessels. In the mestome bundle of third type, the leptome is separated from the stereome by thin-walled parenchyma cells.

In *Festuca elatior* var. *pratensis*, as in *Lolium perenne*, a thin-walled parenchyma sheath surrounds all bundles of the second type, but in all cases thick-walled cells form a closed sheath around leptome and hadrome just inside of parenchyma sheath.

Stereome.—This consists usually of six cells at the margins of leaf and occurs on superior surfaces of all bundles of the first and third types, and occasionally on superior surface of the mestome bundles of second type. It is not, however, strongly developed. Greatest development is reached on superior and inferior surfaces of mestome bundles of carene.

Mesophyll.—This is found between all mestome bundles. The mestome bundles are found not so close as in Lolium perenne. The cells are smaller. The smaller occur on superior face. The epidermal cells of stereome region are thick-walled.

FESTUCA TENELLA WILLD.

(Pl, ix, Fig. 2; Pl. x, Figs. 5 and 6.)

Epidermis.—The epidermis is as strongly developed as in *Festuca elatior* var. *pratensis* though not as large as in *Lolium*. The smaller cells occur on superior surface. The cuticle is thicker on inferior surface than on superior surface. The epidermal cells covering the stereome are thick-walled and not as large as the other epidermal cells.

This dry soil grass has involute leaves and, as Hackel says: "In grasses that do not have such fan-shaped cell groups (bulliform cells) the blade remains always folded or rolled up, or at least open but a little." Bulliform cells do not occur, or only as slight differentiation of epidermal cells.

Trichomes are conspicuous, but only on the superior surface, one to three to each bundle.

Mestome bundles.—There are twelve mestome bundles in a leaf, of three types. First, primary type, open both on inferior and superior surfaces of leaf, *i. e.*, those which have hadrome and leptome respectively in contact with stereome, either in direct contact or are separated from it by several rows of thin-walled parenchyma cells. Second, the secondary type. These are entirely surrounded by chlorophyll-bearing parenchyma. Third, intermediate type. These open inferiorly. Only one bundle of primary type occurs and this is in the carene. The leptome and hadrome are in direct contact with each other. The leptome is separated from the stereome by thin-walled parenchyma cells. Quite a development of thin-walled parenchyma cells occurs above the mestome bundles of carene. Two bundles of the third type occur near the margin of leaf. The cells separating the leptome from stereome are in this case somewhat thicker-walled than those in carene.

The mestome bundles of second type are of two sizes, the largest ones having leptome and hadrome poorly developed, and the smallest having no thick-walled cells.

The thin-walled parenchyma, with its inner closed sheath does not differ from that described in *Festuca pratensis* and *Lolium perenne.*

Stereome.—This seems to be more strongly developed in this species than in *Festuca elatior*, variety *pratensis* and *Lolium perenne.* It occurs on the margin of leaf, and also on inferior surface of all bundles of first and third types, and on inferior surface of all large bundles of secondary type.

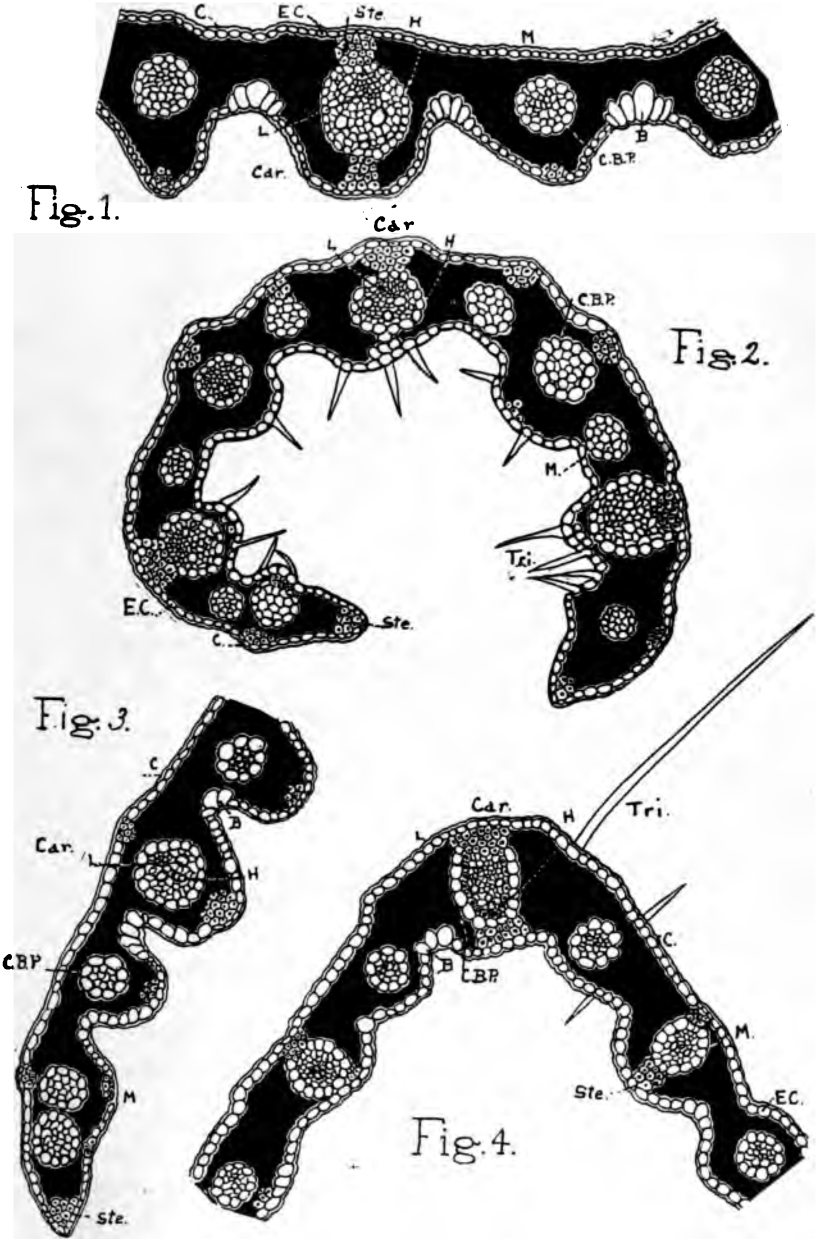
Mesophyll occupies a small area in this species since the mestome bundles are close together.

BROMUS PATULUS M. & K.

(Pl. ix, Fig. 4; Pl. x, Fig. 7.)

This was thought to be *B. racemosus.*

Epidermis.—The large epidermal cells are thicker-walled than in *Festuca* or *Lolium perenne.*—Over the stereome they are smaller and thicker-walled. The cuticle is thicker on superior than on inferior surface. The leaves are very hairy, and trichomes occur both on inferior and on superior surface, but are more numerous on superior surface.


C.
E.C.
Ste.
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M
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Car.
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C.B.P.
Fig. 1.
Car
L
H
C.B.P.
Fig. 2.
M.
Tri.
E.C.
C.
Ste.
Fig. 3.
C
B
Car.
L
H
C.B.P.
M
Ste.
Car.
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Tri.
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C.
B
C.B.P.
M.
Ste.
E.C.
Fig. 4.

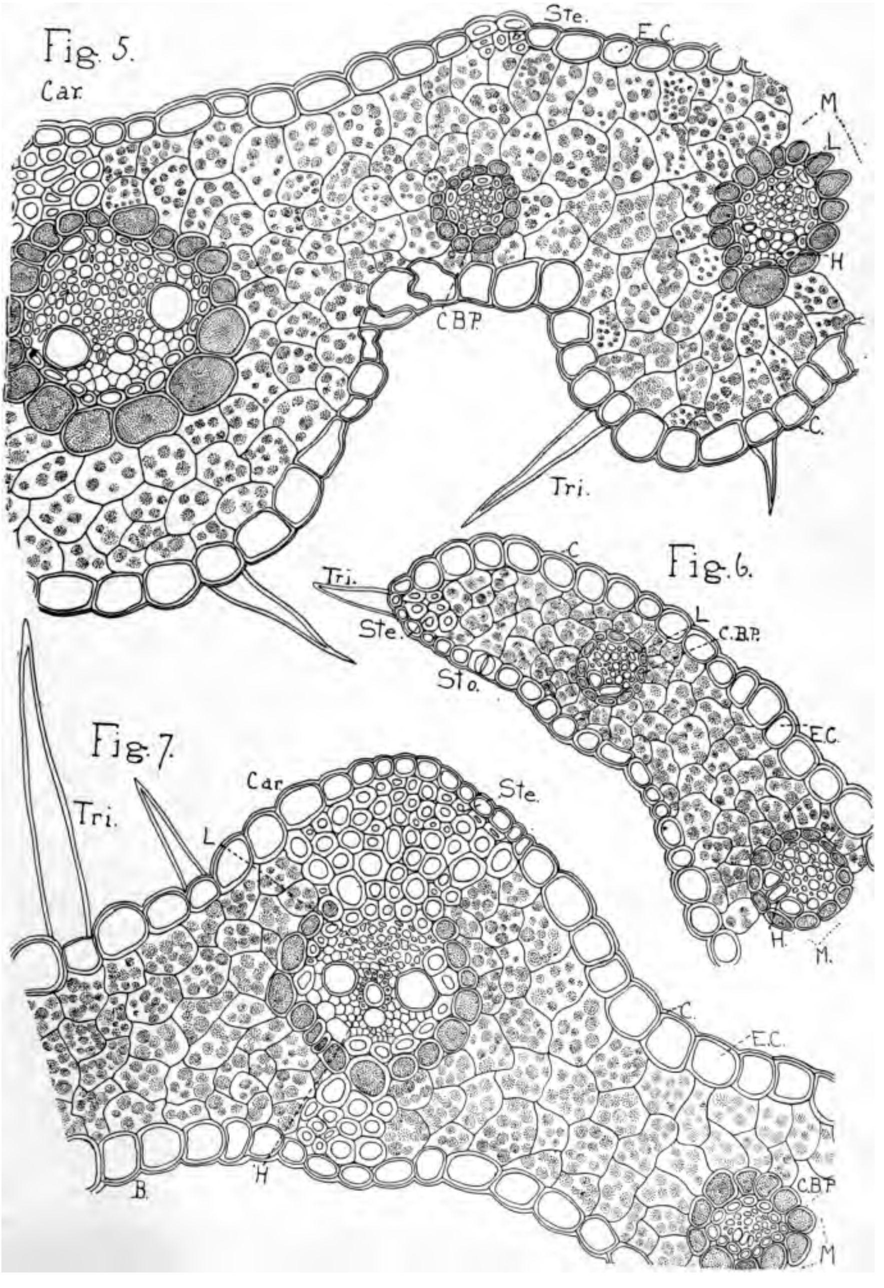
Fig. 5.
Car.
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Fig. 6.
Tri.
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Fig. 7.
Tri.
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E.C.
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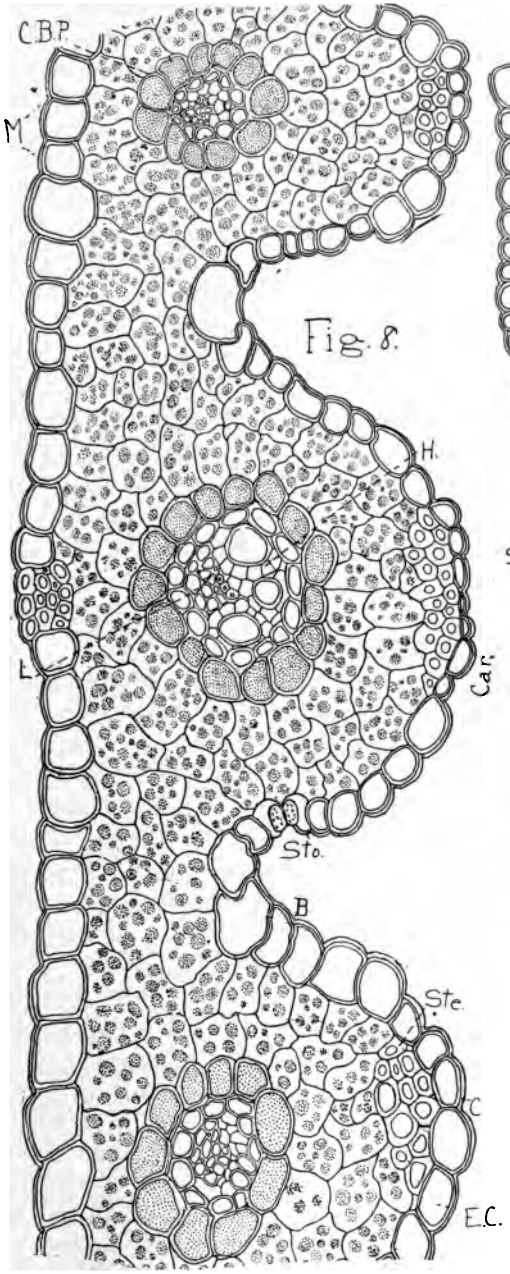

Fig. 8.

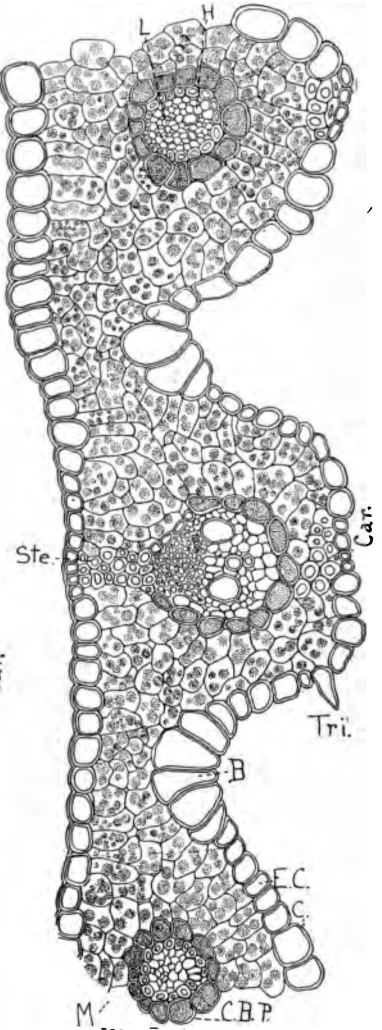

Fig. 9.

Bulliform cells.—The bulliform cells are not greatly differentiated. In a great many cases the cells are hardly to be distinguished from epidermal cells proper. They occur between each mestome bundle and number three.

In the middle of the leaf there are from thirty to thirty-three mestome bundles of three types: primary, secondary and intermediate.

The mestome bundles of secondary type are most numerous, sixteen in each leaf. These bundles are rather small, and occur near the margin of the leaf. Those of the secondary type consist mainly of thick-walled cells with poorly developed pitted vessels. One mestome bundle of second type occurs on each side of mestome bundle of carene.

Three sizes of mestome bundle of first type occur. One is found in the carene. This is the largest; other sizes follow in numerical order, beginning from margin. The smallest is shown in plate IX.

In the two larger, the leptome and hadrome is well developed, and in the smallest bundle the spiral duct in some instances is wanting.

Stereome.—This is quite conspicuous in the carene. Hadrome separated from stereome by colorless parenchyma cells. In carene the stereome is more strongly developed on inferior than on superior surface of mestome bundles. The mestome bundle of second size has the stereome not so well developed on its superior and inferior surfaces as is found in carene. The mestome bundle of third type is of the same size as the smallest of the first type, only they are more numerous.

Stereome is found on the margin of leaf, and numbers from four to six cells; it also occurs on superior and inferior surfaces of all bundles, except those of the second type. It does not occur on either superior or inferior surface of the bundles of second type.

Mesophyll.—This occurs between all mestome bundles. The cells are quite uniform in size.

EXPLANATION OF PLATES.

All drawings were made with the camera, and are drawn to the same scale. The abbreviations used are: C., cuticle; E, epidermis; E. C., epidermal cells; Sto., stoma; Tr, trichomes; B., bulliform cells; Ste., stereome; Mes., mesophyll; C. B. P., chlorophyll-bearing parenchyma; Car., carene; M., mestome bundles; H., hadrome; L., leptome.

PLATE ix, Fig, 1, Festuca elatior, var. pratensis. Fig. 2, Festuca tenella; Fig. 3, Lolium perenne; Fig. 4, Bromus patulus.

PLATE x, Figs. 5 and 6, Festuca tenella; Fig. 7, Bromus patulus.

PLATE xi, Fig. 8, Lolium perenne; Fig. 9, Festuca elatior, var. pratensis.

AN ANATOMICAL STUDY OF THE LEAVES OF SOME SPECIES OF THE GENUS ANDROPOGON.

BY C. B. WEAVER.

The purpose of the following paper and accompanying figures is to make an additional contribution to the work already done toward our knowledge of the leaf anatomy of grasses.

Reference to valuable literature along this line of scientific research may be found in the papers by Misses Pammel and Sirrine, on the genera Sporobolus and Panicum, published in vol. III, of the proceedings of Iowa Academy of Sciences for 1895.

ANDROPOGON PROVINCIALIS.

(Pl. xii. Figs. 2, 3 and 4; Pl. xiv. Fig. 12.)

In this species the epidermal cells (E. C.) are large, nearly round and variable in size. The cuticle (C.) is well developed. The stomata (Sto.) occur in small depressions.

The bulliform cells (B. C.) vary in number from two to six. They seem to merge gradually into the epidermal cells and vary considerably in size. These cells occur between the secondary veins and below the mestome bundles.

In this species four types of bundles occur, viz.: (1) carene, (2) entirely closed, (3) open, (4) larger secondary bundles with stereome (Ste.) both above and below.

The carene (Car.) consists of three large bundles open above and below. The central bundle is but little larger than the secondary bundles. In the hadrome (H) occur the conspicuous pitted and spiral ducts. The chlorophyll-bearing parenchyma cells surrounding the larger bundles are not as conspicuous as those of the smaller mestome bundles. The stereome (Ste.) above the carene is well developed and is wider than the middle larger bundle, while opposite on the lower side of the leaf occur but few stereome cells, and these latter are in direct contact with the epidermal cells. The cells composing the leptome portion (L) of the middle carene bundle are uniform in size.

The uncolored parenchyma cells which occur below and to the side of the middle carene bundle, are large. These cells are in contact with the three large bundles of the carene (Car.) The smaller mestome bundles (M) on either side of the carene occur close together. The chlorophyll-bearing parenchyma cells (C.B.P.) surrounding them are conspicuous. These bundles are not uniform in number on both sides of the mid-rib, which goes to show that the development of the leaf is unequal. On each side of the carene occur four of the larger secondary bundles.

The edges of the leaf are provided with stereome (Ste.) The stereome about the bundles varies in the number of cells.

The cells of the mesophyll (Mes.) occur as dense masses with numerous intercellular spaces. They vary in shape from elongated to spherical. An occasional small trichome (Tri.) (Fig. 4) may be seen.

ANDROPOGON NUTANS.

(Pl. xii, Figs. 1 and 5; Pl. xv, Figs. 14 and 15.)

In this species, as in *A. provincialis*, the epidermal cells (E.C.) are large, nearly round and vary in size. The cuticle (C) is well developed. The conical projections (C. P.) are conspicuous, and more so on the lower than on the upper surface.

Th bulliform cells (B. C.) vary in number from two to five. They are more uniform in number than *A. provincialis*, and do not vary so much in size. They occur between the secondary veins and below the smaller closed mestome bundles (M). In this species, as in *A. provincialis*, occur four types of bundles, (1) carene, (2) entirely closed by surrounding chlorophyll-bearing cells, (3) open, (4) large bundles with leptome (L.), and hadrome (H.), more strongly developed. There occasionally occurs a short and sharply pointed trichome emerging from the mestome bundle of the secondary vein. The secondary bundles are open above and below. Stereome (Ste.) occurs on both sides of these bundles.

The carene differs from that of *A. provincialis* in the number of pitted and spiral ducts. Its parts are all well developed. The stereome below the carene is not so abundant as in *A. provincialis*, but the reverse is true of the stereome above the carene. The uncolored parenchyma cells between the bundles and upper stereome are more numerous than in *A. provincialis*.

The mestome bundles are not so close together in this species as in *A. provincialis*. The larger bundles vary in number

on either side of the carene, while the number as a whole is uniform, forty-one and forty-nine. The edges of the leaves are completely filled with stereome (Ste.). The stereome occurs only on the lower side of the smaller closed bundles, and in sections of this species is not so abundant as in *A. provincialis.* The mesophyll (Mes.) is more abundant in *A. nutans* than in *A. provincialis.* In shape and size the cells are about the same. In this portion we find small intercellular spaces. The uncolored parenchyma cells about the carene occur in about the same proportion as in *A. provincialis.*

ANDROPOGON SCOPARIUS.

(Pl. xiii, Figs. 6 and 8; Pl. xv, Fig. 12.)

In this species the epidermal cells (E. C.) do not differ in detail essentially from *A. provincialis* and *A. nutans.* They are quite variable in size. Cuticle (C.) is well developed. Trichomes (Tri.) are scattered but conspicuous.

The bulliform cells (B. C.) are sufficiently characteristic to distinguish it from all other species studied. They occur as an almost continual row the entire breadth of the leaf with the exception of above secondary bundles, this space is occupied by stereome.

Stereome occurs in groups of from three to eight cells, more uniform in size than in the other species studied. The principal distinguishing feature between this and other members of the genus studied lies in the continuous row of bulliform cells which occurs across the upper portion of the carene (Car.) this, in other species, is occupied by sterome.

The four types of bundles occur in this species as in others studied. The carene is bulged below. Stereome (Ste.) is abundant. The epidermal cells on the lower surface of the leaf below the carene are somewhat irregular with reference to the cell wall, the latter is also stratified.

The uncolored parenchyma occupies the space between the bulliform cells and the bundles of the carene, forming more or less of a continuous row up to and slightly beyond the first secondary bundle, except for such interruptions due to the development of stereome of bundles of third type. Beyond this it is confined to from two to six cells above the mesophyll. Stereome does not occur above carene as in other species studied. Pitted and spiral ducts are large and well developed. Leptome (L.) and hadrome (H.) are well developed in this species.

The mestome portion is compact. The larger secondary mestome bundles occur in sets of three on either side of the carene. The bundles number twenty-four and twenty-eight on either side of carene. The mestome portion extends nearly to the edge of the leaf, where stereome occurs. The edges of the leaf are rounded.

The stereome portion is quite generally distributed and varies not essentially from this portion in other species. The secondary mestome (M.) bundles are not characteristic.

ANDROPOGON SORGHUM.

(Pl. xiii, Fig. 7; Pl. xiv, Fig. 10.)

Cuticle (C.) and epidermal cells (E. C.) are not characteristic. Bulliform cells (B. C.) vary in number from two to eight. Their size is somewhat variable. These cells merge so gradually into the smaller ones which are usually found above the mestome bundles that it is difficult to distinguish them from the epidermal cells on this side of the leaf. The four types of bundles common in other species studied occur also in this species. The carene is distinguished from that of other species studied in that the chlorophyll-bearing parenchyma cells (C. B. P.) are small, not so regular, and do not contain as much chlorophyll as in other species studied. The intercellular space adjoining the ringed duct is large. The stereome (Ste.) above and below carene bundles is conspicuous. Epidermal cells directly below carene are rectangular in shape. The mestome (M.) bundles are not characteristic in this species. The rectangular chlorophyll-bearing parenchyma cells surround the bundles. The mestome bundles are numerous and occupy the same relative position as in other species studied. Edges of leaf have a well-developed stereome. The number of cells varies. The mesophyll (Mes.) is not so dense as in other species. The shape and size of the cells varies considerably. The uncolored parenchyma cells occur above and to sides of upper half of carene. These cells are unusually large, and occupy a large portion of the mid-rib. They gradually become smaller toward the edges of the leaf. Stereome above parenchyma occurs in from two to three rows. The contents of bundles are not essentially different from others already studied. The breadth of the leaf as well as the large mid-rib is sufficient to characterize it.

ANDROPOGON SORGHUM, VAR. HALEPENSE. HACKEL.

(Pl. xiii, Fig. 9; Pl. xiv, Fig. 11.)

The epidermal cells (E. C.) in this species have a thick cell wall and vary somewhat in size, not as much, however, as in some of the other species. Many of the cells, especially the larger ones, are somewhat elongated. The cuticle is well developed. The bulliform cells (B. C.) vary in number from two to four. These gradually blend into the epidermal cells.

The carene (Car.) consists of five bundles, the large bundles of the mid-rib and two smaller closed mestome bundles on each side; the bundle next to the mid-rib is very small and without stereome. Below the second bundles on each side is found a small group of cells. The large central bundle of the carene does not differ from those of other species. In this variety the leptome (L.) consists of large cells, nearly uniform in size. The pitted ducts occur singly; annular duct is rather large. The interior of the bundle contains very little stereome. Chlorophyll-bearing parenchyma cells surround the bundles and are average in size. Stereome (Ste.) occurs on upper side of leaf, and large bundles are in direct contact with the epidermal cells and consist of two quite regular aud distinct layers of cells. The uncolored parenchyma cells are large. The lower surface of mid-rib in this species is decidedly convex. This is also true of *A. sorghum*, but not so marked. The surfaces of the leaf are smooth with the exception of an occasional sharp trichome or conical projection which occurs on the upper surface of the leaf and only in vicinity of the mid-rib. The usual four types of bundles occur. The mestome bundles are not characteristic. The cells of the mesophyll (Mes.) directly surrounding the bundles are elongated. The bundles on either side of the carene occur quite close together. The stereome is confined principally in the vicinity of the carene and larger secondary bundles. The mesophyll portion does not differ materially from that of other species studied. Below stomata (Sto.) occur large intercellular spaces. The edges of the leaf contain conspicuous cells of stereome.

COMPARISON.

A comparison of the species of the genus Andropogon which have been studied at this time shows general similarity in anatomical arrangement of parts, and yet, in each species occur characters sufficient to distinguish it. The bundles have the same general arrangement and structure, except some minor

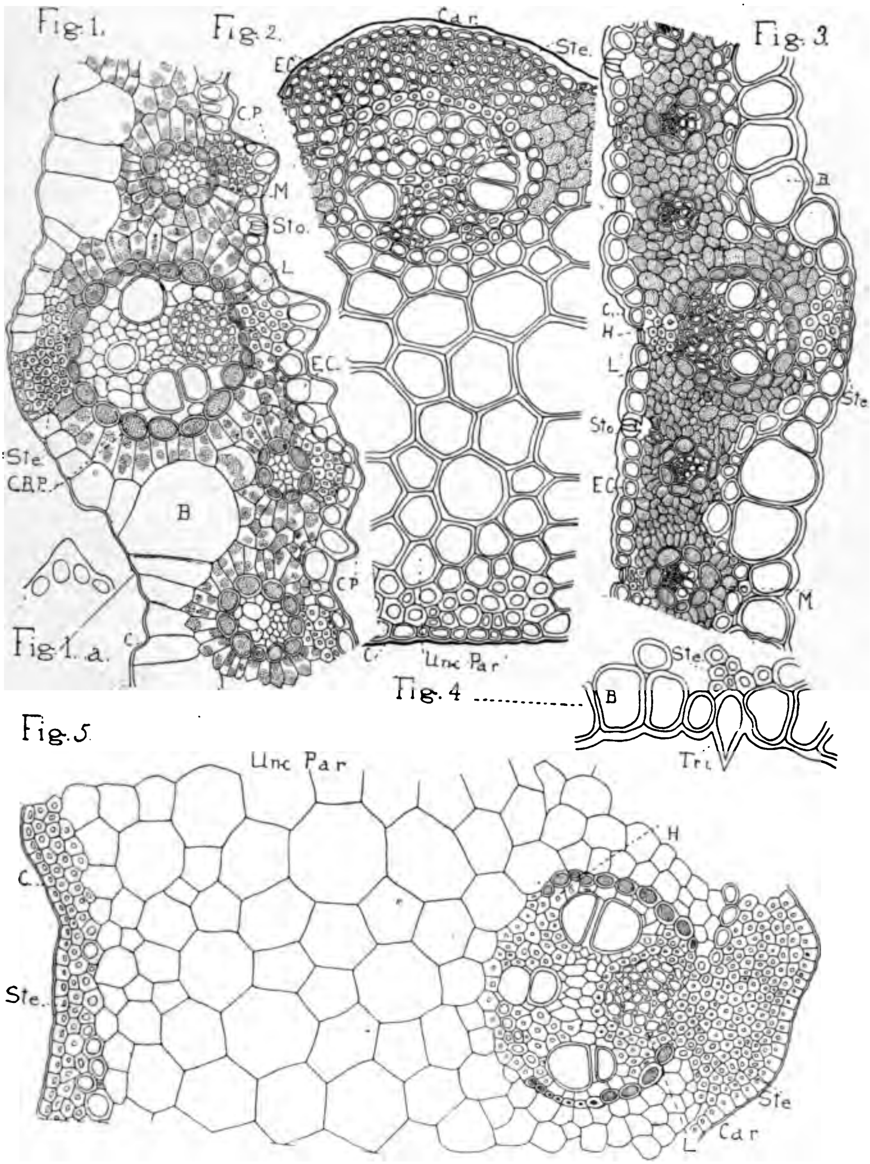
Fig. 1.
Fig. 2.
Fig. 3
Car
Ste.
EC
C.P.
M
Sto.
L
E.C.
Ste
C.B.P.
B
Fig. 1. a.
C
CP
C
Unc Par
B
C
H
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Ste
Fig. 4
B
Tri
Fig. 5
Unc Par
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Ste
Car
L

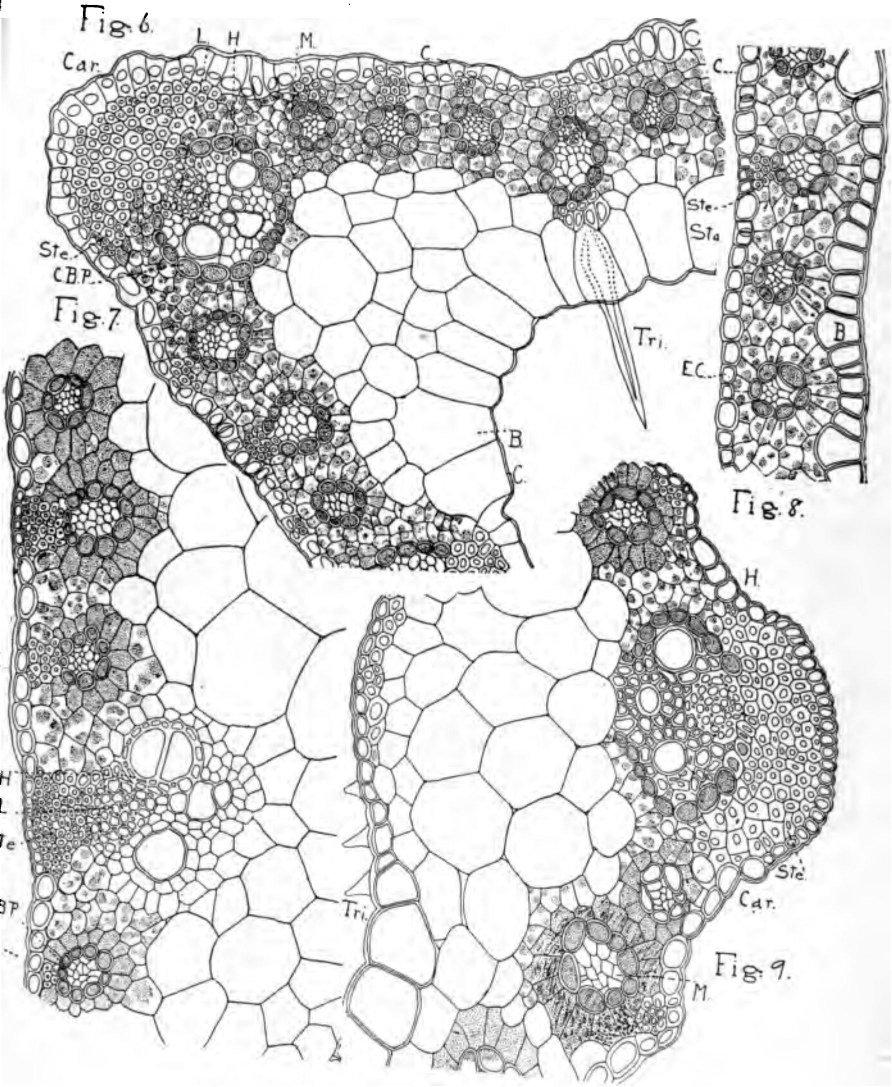
Fig. 6.
L
H
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Car.
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Ste.
C.B.P.
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Tri.
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C.
Fig. 7.
C
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Fig. 8.
H.
Ste
Car.
Fig. 9.
M.

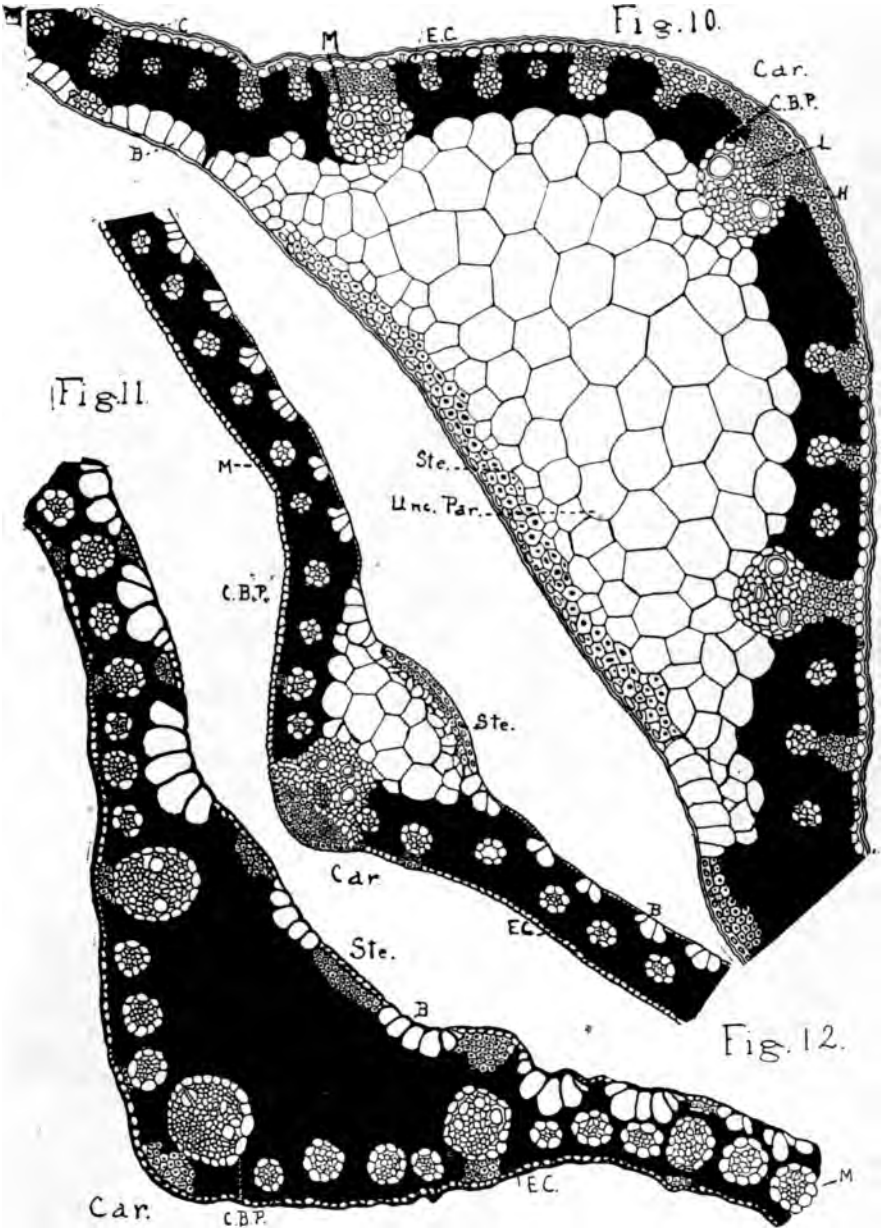
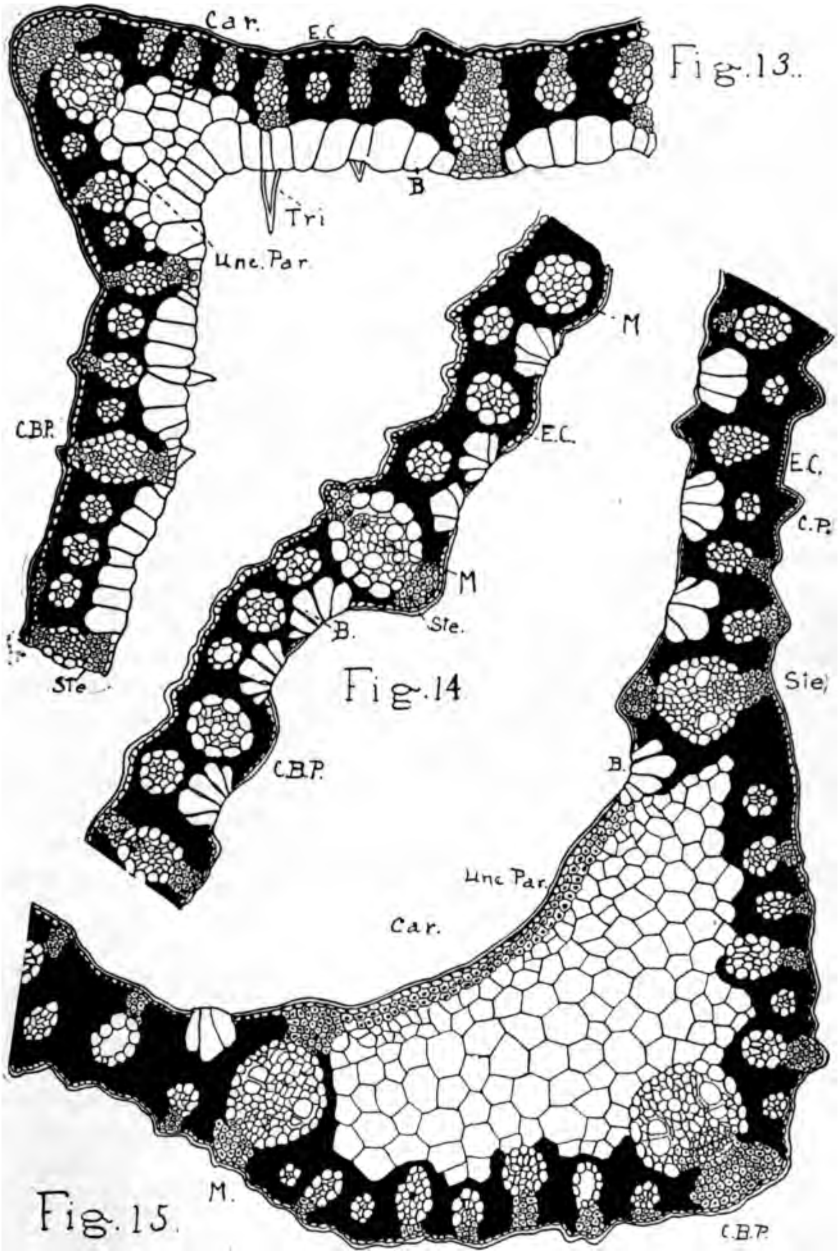


Fig. 10.
M
E.C.
C
Car.
C.B.P.
L
H
B
Ste.
Unc. Par.
Ste.
Car
EC
B
Fig. 11.
M
C.B.P.
Ste.
B
Fig. 12.
Car.
C.B.P.
E.C.
M


Car.
E.C
Fig. 13.
B
Tri
Unc. Par.
C.B.P.
Ste
M
E.C.
M
Ste.
B.
Fig. 14
C.B.P.
E.C.
C.P.
Ste
B.
Unc Par.
Car.
M.
Fig. 15.
C.B.P.

characters. The opened and closed bundles are variable in number and difficult to distinguish, as many of the smaller mestome bundles are very small and close together.

These species can be distinguised by the following key: Bulliform cells in groups of two to four, occasional short trichomes. *A. provincialis.*

Bulliform cells narrow and long, two to five in number, in some cases decidedly unequal, short trichomes very numerous. *A. nutans.*

Bulliform cells three to eight, uniform in size, forming an almost continuous row, also above the carene, trichomes conspicuous. *A. scoparius.*

Bulliform cells vary in number from two to eight, in definite groups, gradually merge into the epidermal cells; smooth. *A. sorghum.*

Bulliform cells vary in number from two to four, grandually blending into the epidermal cells. Trichomes few and small near carene. *A. sorghum*, var. *Halepense.*

CONCLUSION.

In conclusion it may be said that each species of the genus presented here has individual peculiarities which are strong enough to distinguish it from other species of the genus. I believe also that a study of the anatomical characters offered in grasses will show characters enough to distinguish genera and, in many cases, species and even varieties, as for example, in *A. sorghum* and *A. sorghum*, var. *Halepense.* By these studies one may receive material aid in the classification and the determination of many grasses.

Thanks are due to Mr. Barnes of Blue Grass, who kindly sent the leaves of *A. sorghum*, var. *Halepense.*

EXPLANATION OF PLATES.

The same letter is used for the same character in all of the figures. C., cuticle; E., epidermis; E. C., epidermal cells; Sto, stomata; Tri., trichome; C. P., conical projections; B. C., bulliform cells; Unc. Par., uncolored parenchyma; C. B. P., chlorophyll-bearing parenchyma; Mes., mesophyll; Ste, stereome; M., mestome; Car., carene; H., hadrome; L, leptome.

The figures are all drawn with camera to the same scale. Low power with one half inch Beck objective; detailed drawings with one-sixth inch Beck objective.

Figs. 1-9 are reduced three times; Figs. 10-15 not reduced.

PLATE xii, Figs 1 and 5, Andropogon nutans; Figs. 2, 3 and 4, Andropogon provincialis.

PLATE xiii, Figs 6 and 8, Andropogon scoparius; Fig. 7, Andropogon sorghum. Fig. 9, A. sorghum, var. Halepense.

PLATE xiv, Fig. 10, A. sorghum; Fig. 11, A. sorghum, var. Halepense; Fig. 12, A provincialis.

PLATE xv, Fig. 13, A. scoparius; Figs. 14 and 15, A. nutans.

AN ANATOMICAL STUDY OF THE LEAVES OF ERAGROSTIS.

BY CARLETON R. BALL.

This study was undertaken in order to ascertain if the anatomical characters in the leaves of this genus were sufficiently well marked and constant to be of value in identifying the different species. The results of similar studies by others have been encouraging. Prominent among these is the series of excellent papers by Thèodore Holm[1], who has studied six genera-*Uniola*, *Distichlis*, *Pleuropogon*, *Leersia*, *Oryza*, and *Amphicarpum*, and considers the anatomical characters of all except *Distichlis* to be a reliable basis for determining the different species. Emma Sirrine and Emma Pammel[2] have studied *Sporobolus* and *Panicum* and conclude that the species in these genera, so far as studied, may be differentiated by means of their anatomical structure.

In this paper the author has considered six species of *Eragrostis*, viz.: *E. reptans* Nees, *E. pectinacea* Gray, *E. purshii* Schrad., *E. frankii* Meyer, *E. mexicana* and *E. major* Host.

In these species three structural types of mestome bundles occur: primary or open bundles (Pl. XVII, Fig. 8.) in which the chlorophyll-bearing parenchyma sheath is found only at the sides of the bundles and is wanting above and below them; secndary or closed bundles (Pl. XVII, Fig. 13, vein 3,) in which this sheath completely surrounds the bundle, separating the leptome from the stereome below and the hadrome and thick-walled parenchyma from the stereome, mesophyll, or parenchyma above; intermediate bundles in which this sheath is interrupted either above or below the bundle.

[1] A Study of Some Anatomical Characters of No. Am. Gramineæ. Bot. Gaz., Vol. XVI, pp. 166, 217, 275; Vol. XVII, p. 358; Vol. XX, p. 362; Vol. XXI, p. 357; Vol. XXII, p. 403.

[2] Some Anatomical Studies of the Leaves of Spo obolus and Panicum. Proc. Ia. Acad. Sci., 1895. Vol. III, p. 148. (An extended bibliography of this subject may be found in this paper.)

These different types do not always occupy the same relative position in the leaves of the different species.

In the species studied, these bundles are found to occur in three distinct sizes with constant positions. This would have afforded a basis of nomenclature for the bundles but for the fact that it does not hold good for other genera, and hence is not used. However, for convenience in locating the structural types described above, their position in the leaf is indicated by the parenthesis "(carene)" which is the largest vein in the leaf and always central; "(vein 2)" the next smaller veins, occurring at nearly regular intervals between the carene and the edge of the leaf (Pl. xvi, Fig. 2); and "(vein 3)" the smallest veins, which occur in groups of three to six between the medium veins (vein 2) and also between them and the carene.

ERAGROSTIS REPTANS NEES.

(Pl. xvi, Fig. 1; Pl. xviii, Figs. 17 and 18.)

Epidermis.—This, the smallest of the species studied, presents the most striking variations from the general type, especially in the epidermal characters. The walls of the epidermal cells on the superior surface are quite thin, while those of the inferior surface are thicker. The inferior epidermal cells are nearly equal in size, as are those of the superior surface, but these latter are much larger in proportion than those of any other species. Stomata occur frequently on both surfaces, on either side of the mestome bundles. Trichomes are long, slender, pointed, one-celled hairs, occurring in single rows on all bundles. The two adjacent epidermal cells, in some cases, extend obliquely upwards beside the base of the trichome.

Bulliform cells.—The bulliform cells are two or three in number, and in some cases not easily distinguishable from the epidermal cells.

Mestome bundles.—The mestome bundles are thirteen in number, and are all of the intermediate type. The chlorophyll-bearing parenchyma sheath is composed of four or five large cells and is open below. Leptome, hadrome and thick-walled parenchyma are well developed in all the bundles. In the bundles of the carene and vein 2 the mestome sheath is interrupted above by the stereome, but in the other bundles (vein 3) it is continuous.

The carene bundle differs from the other bundles only in being slightly larger, and in having the leptome entirely surrounded by thick-walled parenchyma.

The mesophyll is normal, and the stereome rather small in quantity.

ERAGROSTIS PECTINACEA GRAY.

(Pl. xvi, Fig. 5; Pl. xvii, Figs. 9 and 11.)

Epidermis.—The cuticle of both surfaces is well developed. Walls of superior epidermal cells thicker than those of inferior cells. Epidermal cells of both surfaces more nearly equal in size than in any other species except *E. reptans.* Stomata occur on both surfaces as in the preceding species. Trichomes short, thick, mostly blunt, of irregular size and occurence above the bundles.

Bulliform cells.—From three to five in number, the central one much the largest and flask-shaped, the long neck lying between the adjacent cells.

Mestome bundles.—These are about fifty-seven in number. Forty-six are of the secondary type (vein 3) and eleven of the intermediate type (carene and vein 2). The chlorophyll-bearing parenchyma sheath of the secondary bundles is the most striking character in this species. It is distinctly triangular in outline, with the apex directed toward the superior surface. The lateral cells are elongated transversely to the section, and the inferior or basal cells are small and nearly round. Hadrome, leptome and thick-walled parenchyma are well developed.

The intermediate bundles (carene and vein 2) are open below, with the leptome surrounded by stereome. The chlorophyll-bearing parenchyma sheath in these bundles does not have the triangular outline. Hadrome and thick-walled parenchyma are strongly developed.

The mestome sheath in both types is interrupted above the bundles by stereome. The carene can be distinguished from the other intermediate bundles only by its position.

Stereome.—Stereome occurs below all bundles as a compact group of large cells, twenty to thirty in number, and above the bundles in small groups of three to six large cells. In some of these cells the cavity is in the form of an elongated oval. Stereome also surrounds the leptome in the intermediate bundles and extends upwards partially around the hadrome.

The mesophyll presents no distinctive characters and colorless parenchyma is absent.

ERAGROSTIS PURSHII SCHRAD.

(Pl. xvi, Fig. 2; Pl. xviii, Figs. 15 and 16.)

Epidermis.—The epidermal cells of both surfaces have thinner walls than in *E. pectinacea.* The cells vary considerably in size, those directly above or below a bundle being much smaller than those adjacent to the mesophyll. Stomata occur frequently on both surfaces, and the air spaces are large. Trichomes are longer than in any species except *E. reptans*, and are thick, usually pointed. Above the intermediate bundles they occur in two or more rows.

Bulliform cells.—These, four to seven in number, are large and quite evenly graded in size from the large central cell to the smaller outer cells.

Mestome bundles number twenty-one, of which sixteen are secondary and five are intermediate in type. In the secondary bundles (vein 3) the chlorophyll-bearing parenchyma sheath is nearly round in outline and composed of seven or eight subcircular cells. Hadrome, leptome and thick-walled parenchyma are not so well developed as in the preceding species.

The intermediate bundles (carene and vein 2), five in number, are open below. Hadrome, leptome and thick-walled parenchyma are well developed, the latter especially so. The chlorophyll-bearing parenchyma sheath is composed of from ten to fifteen cells.

The mestome sheath is continuous above and sometimes below the secondary bundles, but is interrupted by stereome above the intermediate type. The carene is but little enlarged and not easily distinguished from vein 2 except by its position.

Stereome is present in quantity both above and below the intermediate bundles and occurs in small groups of three or four cells in the secondary bundles. The mesophyll passes beneath some of the secondary bundles as a single layer of cells.

ERAGROSTIS FRANKII MEYER.

(Pl. xvi, Fig. 6; Pl. xvii, Figs. 10, 12 and 12a.)

Epidermis.—Walls of the epidermal cells slightly thinner than in *E. purshii.* The epidermal cells of the inferior surface vary greatly in size, those beneath the bundles being much smaller than those beneath the mesophyll. Stomata are less frequent in this than in the other species. Trichomes are short, rounded or pointed, and occur on all bundles.

Bulliform cells.—These are five or six in number, are more evenly graded in size than in any other species.

Mestome bundles.—The mestome bundles are thirty-five in number, representing all three types. Of the primary type (vein 2) there are four bundles, in which the leptome, hadrome and thick-walled parenchyma are well developed. These veins (vein 2) are enlarged on the superior face but not on the inferior face. The chlorophyll-bearing parenchyma sheath consists of four or five cells on each side of the bundle, being interrupted below by stereome and above by a few cells of thick-walled parenchyma.

There are thirty secondary bundles (vein 3) containing normal leptome, hadrome and thick-walled parenchyma. The chlorophyll-bearing parenchyma sheath is subpyramidal in outline and composed of five to seven large, subcircular cells with two smaller cells below. The intermediate type is found only in the carene and is open below. Leptome, hadrome and thick-walled parenchyma are strongly developed, the latter passing down to the side of the leptome, which is surrounded by stereome.

The mestome sheath is continuous above the secondary bundles, but above the primary bundles it is interrupted by stereome and above the intermediate bundles by colorless parenchyma.

Carene.—The carene, already discussed as the intermediate bundle, is much enlarged on the inferior side and somewhat so on the superior side. It contains much mesophyll and stereome and some colorless parenchyma.

Stereome occurs in small quantities both above and below the primary and secondary bundles and in much larger quantity in the carene. Directly beneath the center of the carene the stereome is normal in appearance (at x pl. xvii, Fig. 12a) but on either flank it is curiously modified (z pl. xvii, Fig. 12a.) The cell wall is much thinner and does not have the strong greenish yellow color of the normal cell wall. The inner portion of the cell is dark colored and in the very center is a small black dot or cavity. This modified stereome is also found in the same part of the carene of *E. mexicana* and *E. major*. Stereome also surrounds the leptome in primary and intermediate bundles.

Mesophyll is abundant in the enlarged carene and normal elsewhere in the leaf. Four or five cells of colorless parenchyma are found in the carene between the stereome and the chlorophyll-bearing parenchyma sheath.

ERAGROSTIS MEXICANA.

(Pl. xvi, Fig. 3; Pl. xvii, Figs. 7 and 8.)

Epidermis.—The walls of epidermal cells intermediate in thickness between those of *E. purshii* and *E. pectinacea.* Epidermal cells, small below the bundles and large below the mesophyll. Stomata frequent on both surfaces. Trichomes short, thick, one-celled, occurring on all bundles.

Bulliform cells, five to six in number, the central one large and broad.

Mestome bundles.—There are forty-one mestome bundles, of the primary and secondary types. The primary bundles (carene and vein 2) are nine in number, with well-developed hadrome, thick-walled parenchyma and leptome, the latter surrounded by stereome. In the carene the chlorophyll-bearing parenchyma sheath is interrupted above the bundle by colorless parenchyma, but in the other primary bundles (vein 2) by thick-walled parenchyma.

The thirty-two secondary bundles are surrounded by a chlorophyll-bearing parenchyma sheath composed of eight or nine large cells, the two inferior cells having less chlorophyll than the rest. Leptome, hadrome and thick-walled parenchyma are not strongly developed.

The mestome sheath is continuous above the secondary bundles (vein 3) but is interrupted in the primary bundles (vein 2) by stereome or, in the carene, by colorless parenchyma.

The carene is very large, the bundle being in the inferior part of it and subtended by a large quantity of stereome, while the upper part of it is filled by fifteen or twenty large cells of colorless parenchyma, flanked by mesophyll.

Stereome is present in the usual quantity about the secondary bundles (vein 3) and in greater quantity above and below the primary bundles. Mesophyll is found abundantly in the carene, and as usual between the secondary bundles. Colorless parenchyma occurs only above the carene bundle.

ERAGROSTIS MAJOR HOST.

(Pl. xvi, Fig. 4; Pl. xvii, Figs. 13, 14, 19 and 20.)

Epidermis.—The walls of inferior epidermal cells are thick; those of the superior surface, as in *E. mexicana.* Stomata occur regularly on both surfaces. The trichomes are like those of the preceding species.

On the margins of the leaves, and on the median nerve of the sterile and flowering glumes occur numerous small button-shaped projections—the scent glands. (Pl. xvii, Figs. 19 and 20.)

Prof. Wm. Trelease[3] says of these glands: "Morphologically the glands are epidermal structures consisting of a single layer of cells, the outermost of which are but little different from those of the adjacent epidermis, but gradually elongating vertically.

Those at the center of the gland are considerably elongated at right angles to the surface, as is usual in epidermal secreting cells, but occasionally septate. While the peripheral cells have thick-pitted walls, and resemble the other cells of the epidermis in having transparent, watery contents, those at the center are much thinner-walled, and filled with coarsely granular yellow protoplasm. As compared with the unmodified epidermal cells, these elongated glandular cells are also thin-walled at top, where, in common with the other elements of the epidermis, they are invested with a rather heavy cuticle. In some cases this membrane is seen to be free from the crater of the gland in the form of a blister, while in others it had been ruptured, so that only fragments are present."

Bulliform cells.—These are small in proportion, especially above the carene, and vary from four to six in number.

Mestome bundles.—Thirty-one in number, of the secondary and intermediate types. Of the secondary type (vein 3) there are twenty-four, surrounded by a chlorophyll-bearing parenchyma sheath of eight or nine large cells, and containing leptome, hadrome, and thick-walled parenchyma. The intermediate bundles (carene and vein 2) are seven in number, open below, and contain strongly developed hadrome and thick-walled parenchyma, with leptome in greater quantity than usual, and entirely surrounded by stereome.

The mestome sheath is continuous above the secondary bundles, but interrupted by stereome above the intermediate bundles of vein 2 and by colorless parenchyma above the carene bundle.

The carene is much enlarged and contains a few cells of colorless parenchyma and considerable mesophyll. The latter is normal in quantity in the rest of the leaf.

[3] The Glands of Eragrostis major, Host, Proc. Soc. Prom. Agr. Sci., 1889, p 70.

There is more stereome above and below the secondary bundles, than in *E. mexicana*, and strong groups are found about the intermediate bundles.

CONCLUSIONS.

The results of this study are embodied in the analytical key which follows. The characters given will clearly separate the different species, though, with the exception of the peculiar glands of *E. major*, the differences between *E. mexicana* and *E. major* are not well marked. For instance, the number of cells of colorless parenchyma is constant in neither species, nor is there an absolute line of demarcation between these cells and the mesophyll. Again, while the carene bundle of *E. mexicana* is classed as an intermediate bundle, it will be noticed that the three large cells which form the superior part of the chlorophyll-bearing parenchyma sheath resemble very closely, in their shape, cell-wall, and the almost entire absence of chlorophyll, the adjacent cells of colorless parenchyma.

In conclusion, the author wishes to acknowledge his obligation to Prof. L. H. Pammel, under whose efficient direction the work has been done, for his invaluable assistance and advice; also to Miss Charlotte M. King, artist for the botanical department, for kind suggestions and assistance. Thanks are also due to Mr. F. R. Clements, of Lincoln, Neb., and Mr. W. D. Barnes, of Blue Grass, Iowa, who kindly furnished specimens for study.

ANALYTICAL KEY.

All mestome bundles provided with a chlorophyll-bearing parenchyma sheath; mestome sheath composed of a single row of cells radially arranged; stereome above and below all bundles.

A. Superior epidermal cells of nearly equal size and all larger than the largest of the inferior epidermal cells; trichomes one-celled, long, slender, pointed. *E. reptans.*

B. Superior epidermal cells unequal in size and not larger than the inferior cells; trichomes short and thick.

I. Chlorophyll-bearing parenchyma sheath in bundles of secondary type (vein 3) distinctly pyramidal in outline, apex directed toward superior surface; lateral cells of sheath elongated transversely to the section. *E. pectinacea.*

II. Chlorophyll-bearing parenchyma sheath in bundles of secondary type (vein 3) round or oval in outline.

a. Carene not enlarged (or but little), especially on inferior side, not easily distinguishable from vein 2; trichomes equal in length to

one-fourth or one-third the width of section; no colorless parenchyma. *E. purshii*.

b. Carene enlarged preceptibly, especially on inferior side, easily distinguishable; trichomes equal in length to one-tenth or one-sixth of the section; colorless parenchyma present.

1. Leaf small; upper surface presents a fluted appearance in section; carene and vein 2 strongly developed, the latter on superior side especially; chlorophyll-bearing parenchyma sheath in secondary bundles (vein 3) subpyramidal in outline; cells of same subcircular and the inferior cells much smaller than the rest. *E. frankii*.

2. Leaf large, fluted but little on superior surface; carène enlarged on inferior side only; vein 2 not enlarged; chlorophyll-bearing parenchyma sheath circular in outline; cells subcircular, equal in size.

† Colorless parenchyma, fifteen to twenty cells, interrupting the mestome and chlorophyll-bearing parenchyma sheaths above the bundles in the carene. *E mexicana*.

†† Colorless parenchyma, three to five cells, interrupting the mestome sheath above the bundle in the carene; small button-shaped scent glands, numerous on the margins of all leaves and on the median nerve of both sterile and flowering glumes. *E. major*.

EXPLANATION OF PLATES.

All the figures were drawn from nature by the author and prepared for the engraver by Miss Charlotte M. King, artist for the botanical department.

The abreviations used are: C., cuticle; E. C, epidermal cells: Tr., trichome; Sto, stoma; B., bulliform cells; Ste., stereome; Mes., mesophyll; M. S., mestome sheath; C. P., colorless parenchyma; C. B. P., chlorophyll-bearing parenchyma; H., hadrome; L., leptome; Sup., superior; Inf., inferior; Car., carene; Vein 2, vein next smaller than carene; Vein 3, smallest veins.

PLATE XVI. All drawings on this plate were made with camera, and drawn to the same scale. Fig. 1. *E. reptans*, carene to margin: Fig. 2, *E. purshii*, carene to second vein 2; Fig. 3, *E. mexicana*, carene to first vein 2; Fig. 4, *E. major*, carene to first vein 2; Fig. 5, *E. pectinacea*, carene to first vein 2; Fig. 6, *E. frankii*, carene to first vein 2. Mesophyll and epidermis colored black.

PLATE XVII. All drawings on this plate, except Fig. 12a, made with a one-sixth inch objective. Fig 12a, drawn with a one-tenth inch oil immersion objective. All reduced one-half. Fig. 7, *E. mexicana*, carene and vein 3, primary and secondary types, respectively; Fig. 8, *E. mexicana*, vein 2, primary type; Fig. 9, *E. pectinacea*, carene, intermediate type, and vein 3, secondary type; Fig. 10, *E. pectinacea* vein 2, intermediate type; Fig. 11, *E. frankii*, vein 2, primary type; Fig 12, *E. frankii*, carene, intermediate type, and vein 3, secondary type; Fig. 12a, *E. frankii*, inferior part of carene; X, normal stereome; Z, modified stereome.

PLATE XVIII. All drawings on this plate made with a one-sixth inch objective; all reduced one-half. Fig. 13, *E. major*, vein 3, secondary type, vein 2, intermediate type; Fig 14, *E. major*, carene, intermediate type; Fig. 15, *E. purshii*, vein 2, intermediate type; Fig. 16, *E. purshii*, carene, intermediate type and vein 3, secondary type; Fig. 17, *E. reptans*, veins 2 and 3, intermediate type; Fig. 18, *E. reptans*, carene and vein 3, intermediate type; Fig. 19, *E. major*, scent gland, superficialview; Fig. 20, two scent glands on leaf margin, *E. major*.

Fig. 1.

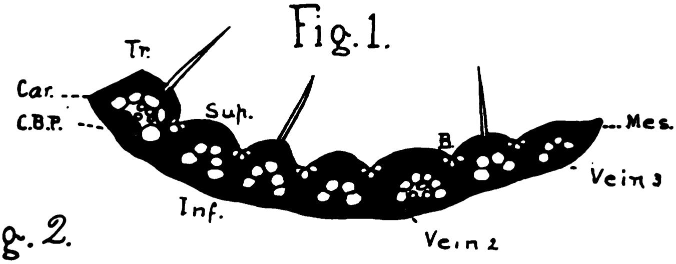


Fig. 2.

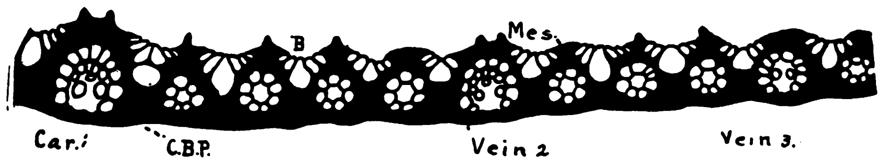


Fig. 3.

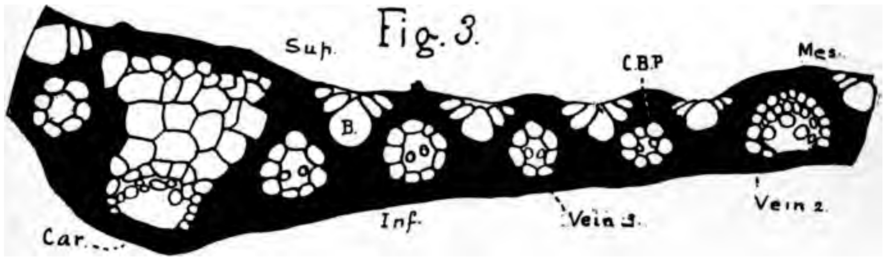


Fig. 4.

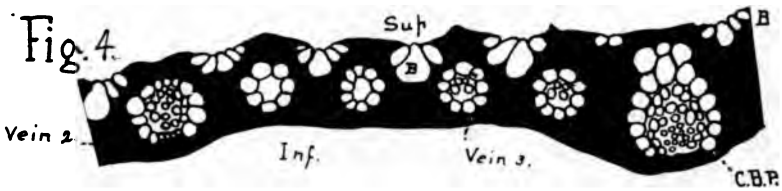


Fig. 5.

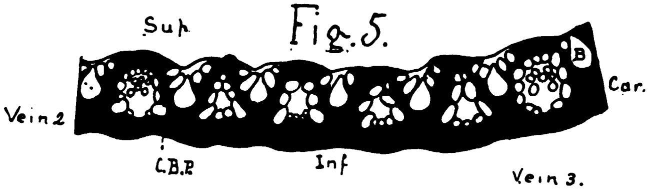
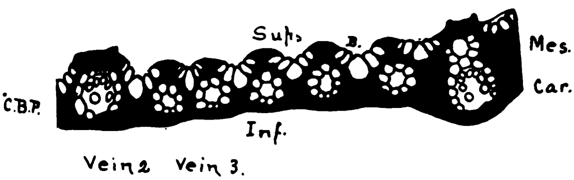
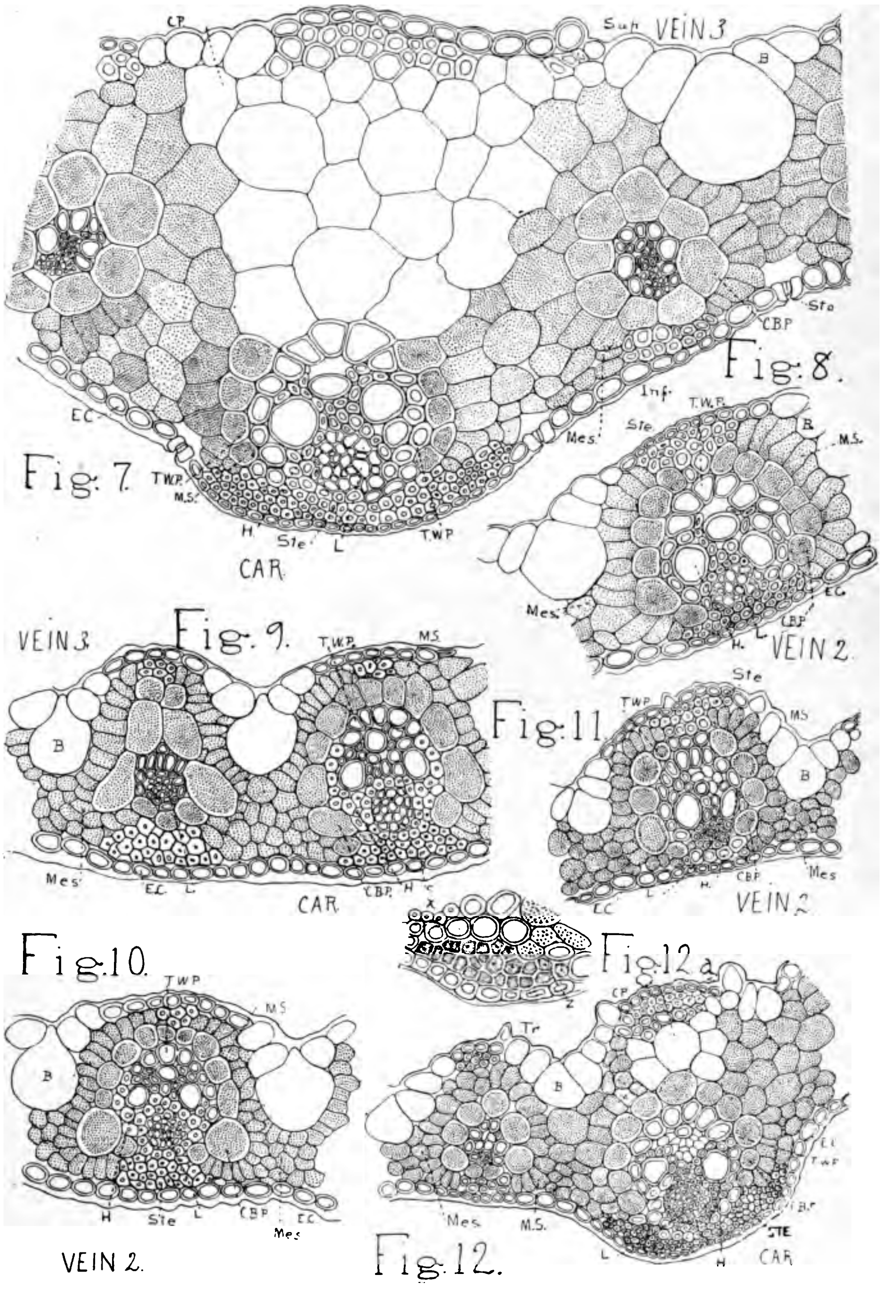


Fig. 6.





CP
Sub
VEIN 3
B
Sto
CBP
Fig: 8.
Inf.
T.W.P.
Ste
B
M.S.
Mes
EC
Fig: 7
TWP
M.S.
H
Ste
L
TWP
CAR
Mes
EC
CBP
H
L
VEIN 2
VEIN 3
Fig: 9.
T.W.P.
MS
B
Mes
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CAR
Fig: 11
TWP
Ste
MS
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VEIN 2
Fig. 10.
TWP
MS
B
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CBP
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VEIN 2.
X
Z
Fig. 12 a
CP
Tr
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Fig. 12.

PLATE XVIII.

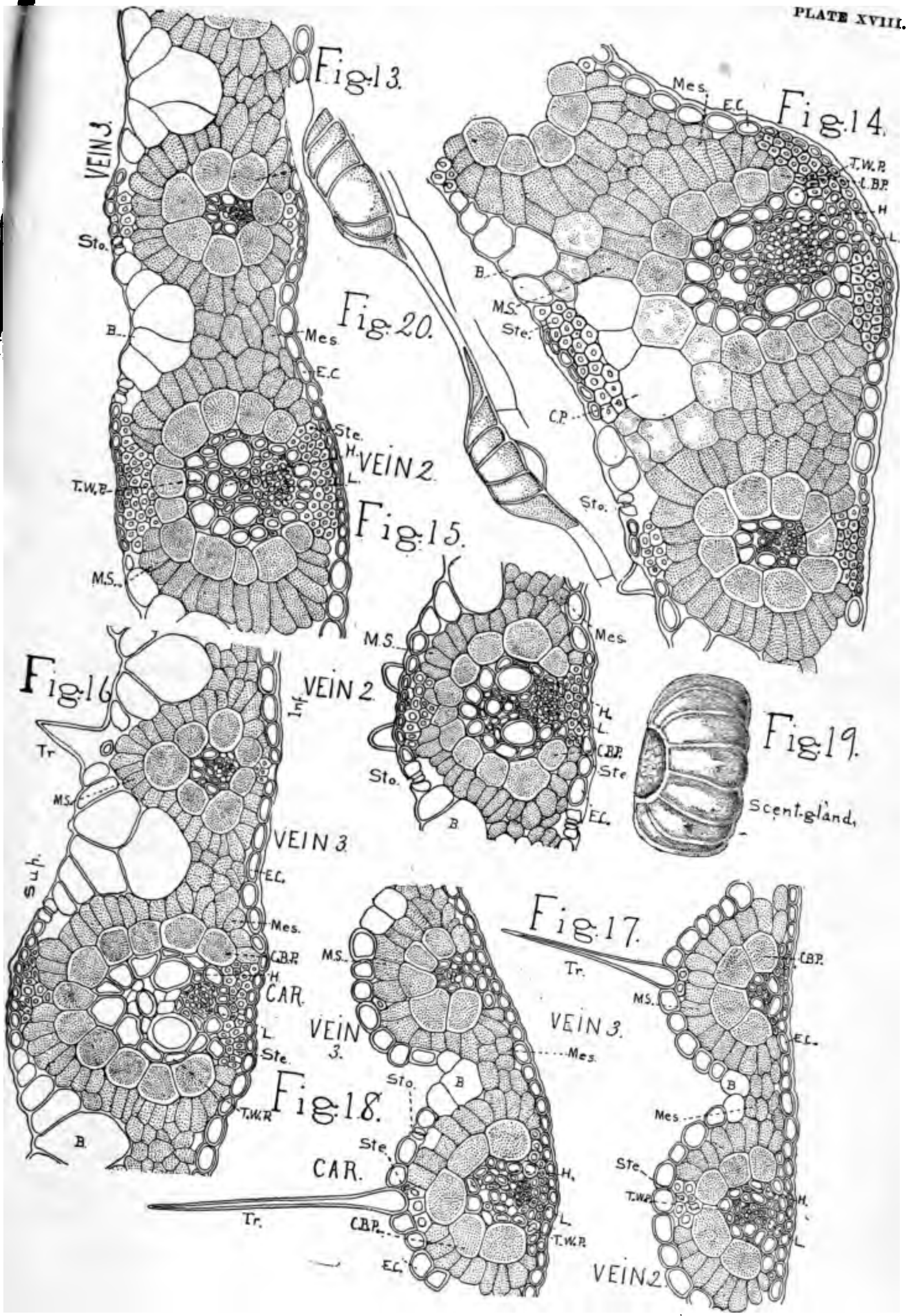


Fig. 13.
VEIN 3.
Sto.
B.
Mes.
E.C.
Ste.
H.
L.
VEIN 2.
T.W.P.
M.S.
Fig. 20.
Fig. 14.
Mes.
E.C.
T.W.P.
C.B.P.
H.
L.
B.
M.S.
Ste.
C.P.
Sto.
Fig. 15.
M.S.
Mes.
H.
L.
C.B.P.
Ste.
Sto.
B.
E.C.
Fig. 19.
Scent-gland.
Fig. 16.
VEIN 2.
Inf.
Tr.
M.S.
VEIN 3.
Sup.
E.C.
Mes.
C.B.P.
H.
CAR.
L.
Ste.
T.W.P.
B.
VEIN 3.
Fig. 18.
M.S.
Sto.
B.
Ste.
CAR.
Tr.
C.B.P.
E.C.
H.
L.
T.W.P.
Mes.
Fig. 17.
Tr.
VEIN 3.
C.B.P.
M.S.
E.L.
B.
Mes.
Ste.
T.W.P.
H.
L.
VEIN 2.

THE USES OF FORMALDEHYDE IN ANIMAL MORPHOLOGY.

BY GILBERT L. HOUSER.

By the term *formaldehyde*, I wish to designate a 40 per cent solution of the gas formaldehyde in water. Several articles answering to this description have been placed on the market under trade names such as the "Formalin" of Schering, the "Formol" of Merck, and the "Formalose" of Richards & Co. So far as I have tested these various preparations, they all agree as to composition, and yield perfectly similar results. My attention was first directed to formaldehyde as a morphological reagent in July, 1894, and I have been using it in my work, and have experimented with it in various directions since that time. It certainly possesses several most remarkable properties; so remarkable, in fact, that certain phases of laboratory work in animal morphology are ultimately destined to undergo a revolution through its use.

I. FORMALDEHYDE AS A GENERAL PRESERVATIVE.

It has been urged many times that the zoological specimens placed in the hands of students for class-work are too often mere caricatures of the living animals themselves, and that various erroneous conceptions about nature are thus sure to arise. Granting that we should, as far as possible, use fresh material for study, the fact remains that there are many animals which must be preserved if we are to study them at all. The whole of the group Echinoderma, and, with one exception, all the members of the Coelentera, are cases in point. Such animals have to be preserved at some distant point and transported to us. Now, formaldehyde has its most important and its most far reaching application in this particular field of morphological work. It is the best general preservative of material for class-work that has yet been discovered. The peculiar qualities which confer upon it this distinction are as follows:

First.—It does not extract water from the tissues and consequently it does not shrink them. The distortion of an animal will be in direct proportion to the shrinkage of its tissues, and this, in turn to the amount of water extracted. Hence it was that our attempts to preserve such watery forms as medusæ, ctenophores, etc., with our old media were always failures; our preserving fluids dehydrated them. Formaldehyde, however, will preserve almost every form of animal life known without any distortion. Such a fact opens up possibilities for class instruction which are almost ideal.

Second.—Most of the pigments of the animal body are not extracted by formaldehyde. This quality ranks next in importance to the preceding one. Natural coloration enters so largely into our conceptions of animals that bleaching during the process of preservation is always to be deplored. With alcohol as the preserving fluid, all parts are certain to be brought to the same level of dingy yellow after a time. But with formaldehyde, we can hope to show our students the colors which actually characterized the animals during life.

Third.—It does not render tissues opaque. On the contrary it retains the transparency of the living parts, or may even add to it. Nerves are aften more readily traced after preservation than during life.

Fourth.—It leaves tissues as flexible as it is possible for them to be. The natural elasticity of the parts is usually perfectly retained, and brittleness never occurs.

Fifth.—It is a very convenient reagent for collectors to use. The preserving medium is a dilute solution of the commercial article in water. A collector can carry enough formaldehyde in a bottle which will slip into his coat pocket to make several gallons of the preservative. The water used in diluting it should always be that from which the collection is made, either salt or fresh, as the case may be.

Sixth.—It is a very cheap reagent. The commercial article is imported duty free by the State University of Iowa in 100-pound lots at a cost of 40 cents per pound. When made up in a 4 per cent solution the cost of a gallon is thus only 12 4-5 cents.

We might, in fact, summarize the various desirable qualities of formaldehyde as a preserving medium as being "very close to the ideal." A reagent which preserves faithfully all natural features just as they were during life. That it is infinitely

superior to alcohol is the verdict of everyone who has thoroughly tested it. It is true that it was severely criticized soon after its introduction into America, by certain workers who failed to secure *permanent* preservation with it. In all such cases of failure the solutions employed were very weak ones. A proper strength of solution is a very important detail. A solution of 4 per cent strength—that is, one containing

Commercial formaldehyde	4 volumes,
Water	96 volumes,

is perfectly safe for most objects. Of course, stronger solutions are required for special cases, and slightly weaker ones for others.

Certain precautions in the use of this reagent require notice here:

First.—The gas is quite volatile, and the containing jar must be kept tightly sealed. If it be impossible to entirely prevent evaporation, changing the solution occasionally will answer perfectly well.

Second.—The solution being an aqueous one it is liable to freeze. This probably appears, at first, a very serious matter, because we are so used to alcohol as a preservative, and this does not become frozen.

Third.—The gas is irritating to the eyes, nose and throat. The effect, however, is merely temporary. Prolonged washing in water before a dissection is to be made will remove much of the reagent and reduce the annoyance to a minimum. Alcohol of 70 per cent strength appears to extract formaldehyde more rapidly than does water, but it is not always practicable to use it.

II. THE USE OF FORMALDEHYDE IN FIXING AGENTS.

In cellular biology the choice of a fixing agent means a great deal. All the conceptions which we build up about the cell appear to rest primarily upon the character of the reagent which was used in killing it. While we constantly seek to keep in our preparation the features of the living cell, how far short of the ideal we often fall every histologist knows. It is probable that certain recent investigations in cell structure will have to be gone over again because of too blind a faith in the fixing agents which were used.

Formaldehyde alone is not suitable for general cytological work. It has a tendency to produce a vacuation in protoplasm

which is very deceptive. It may, however, be combined with other reagents with superior results. When added to picric acid there is given one of the most delicate fixing agents yet imagined; one which appears to faithfully preserve every detail of structure, and which also permits of subsequent treatment in any desired way. Mixtures of formaldehyde, chromic acid, and acetic acid; or of formaldehyde, platinic chloride, and acetic acid are also very desirable. The principle involved here appears to be that formaldehyde may often be advantageously substituted for osmic acid in such mixtures on account of its superior penetration and the absence of a tendency to overfixation. In all these cases formaldehyde is to be used pure, not diluted.

III. FORMALDEHYDE IN NEUROLOGICAL WORK.

I have been impelled to make a critical examination of neurological methods in connection with a certain line of investigation in which I am engaged. Of course the technique employed in the study of any nervous system is necessarily highly specialized, but the following notes have a general application. Formaldehyde may justly claim a place in neurological methods. Its chief uses are:

First.—It is an excellent hardening agent for the brain, where anatomical methods alone are to be employed. It hardens with surprising rapidity, so that after a week or ten days a fairly large brain can be thoroughly studied.

It also preserves the form and color of the several parts. Its only undesirable effect lies in the increase in volume which is given by a solution of just moderate strength.

This tendency to swell the parts may be lessened by the use of a strong solution, one containing 10 to 20 per cent of the commercial article. It has also been recommended by various workers that a mixture of formaldehyde and alcohol be used, the tendency of the latter to shrink tissues, offsetting the swelling action of the former. Messrs. Parker and Floyd believe that they have struck the proper balance in the following mixture:

95 per cent alcohol	6 volumes,
2 per cent formaldehyde	4 volumes,

in which a barely perceptible increase in the size of the brain occurs. I believe that it is well to double the strength of the formaldehyde in this mixture, and I am accustomed to do so in my own work.

Second.—Formaldehyde has an application in those methods used for tracing the course of medullated nerve fibers. All such methods, whether the original Weigert or some modification of it, are usually long and tedious, the time required frequently being some months. This length of time is often a very serious objection. Formaldehyde can be introduced in these methods for the purpose of rapidly giving firmness to the nervous tissue, and then subsequent steps may follow in quick succession. In this way the time may be reduced to ten days for the whole process.

Third.—In the study of nerve cells formaldehyde may now claim a place in the beautiful impregnation method of Golgi. The application is made in Golgi's "rapid" method, and consists in the substitution of pure formaldehyde for the 1 per cent osmic acid of the hardening mixture. The advantages resulting from this substitution may be an increased clearness of the subsequent silver impregnation, or in the slightly wider latitude of time during which hardening may occur. The physiological condition of the nervous tissue appears to be a very important factor in all Golgi work; and perhaps formaldehyde is less sensitive to these differences than osmic acid. However that may be, osmic acid in this method cannot be dispensed with. Workers should use both hardening mixtures side by side. The results attained by one will supplement those of the other in a most valuable way, thus virtually doubling the efficiency of the study as a whole.

THE NERVE CELLS OF THE SHARK'S BRAIN.*

BY GILBERT L. HOUSER.

The sharks are of the greatest interest to the morphologist on account of the many ancestral characters of their organization. The researches of recent years indicate that they represent quite well the primitive stem of the jaw-bearing vertebrates. With this fact in mind, the importance of the study of the shark's brain is at once apparent. For obvious

* The following brief notes are to be considered as in the nature of a mere preliminary communication on this subject.

reasons modern neurological investigation has been largely concerned with the mammalian brain in general and the human brain in particular. But the structures here are highly specialized, and their significance cannot always be thoroughly understood. In order to unravel the tangled threads of the complex neurological skein, the study of some primitive type of brain is an absolute necessity. The brain of the shark is the one to which we naturally turn for this purpose because of the morphological position which it occupies.

The several parts of the brain are arranged in almost perfect longitudinal series, and are well separated from each other. The *prosencephalon* is a relatively large, unpaired, globular mass. Its ventricle is imperfectly divided into lateral ventricles. A very prominent olfactory apparatus projects anteriorly. On the dorsal surface there are to be seen two slight swellings which may be taken as the anlages of the cerebral hemispheres of higher forms. The *thalamencephalon* is narrow, open dorsally, and the choroid plexus passes in to form a thin roof. The epiphysis arises just behind this point. It is long and slender, and ends in a dilation which is attached to the membranous roof of the skull. Both the *optic lobes* and the *cerebellum* retain the primitive condition of hollow outgrowths. The cerebellum is relatively quite large, and is thrown into transverse folds. The large size is evidently related to the swimming habits of the animal. The fourth ventricle of the *medulla oblongata* is widely open. Its sides are thickened, and project anteriorly as the restiform bodies.

The microscopic structure of the shark's brain was investigated by a few of the older workers, Viault, Rohon, and Sanders requiring especial mention here, The application of silver impregnation by Golgi to the study of nerve cells has, however, opened a new era in neurology, and has made necessary the reinvestigation of every species of nervous system. While the older methods of research had brought out certain general facts about the structure of the shark's brain, it is only through the application of the Golgi method that we can hope to acquire a thorough knowledge as to its ultimate cellular structure. I will enumerate briefly the most important results which I have already reached.

In the fore-brain the nerve cells are large and very conspicuous. They are not arranged in layers, neither do they have a pyramidal form. The prevailing type presents an oblong cell

body from which three or four dendrites radiate indifferently in every direction. The dendrites do not branch very much, but there are so many of them that a very tangled complex is given.

In the mid-brain the ependyma cells are highly developed. Their processes run straight out through the whole of the nervous matter, giving a characteristic appearance to this part of the brain. The nerve cells appear to be somewhat better differentiated than in the fore-brain. Near the outer surface there are cells which send their dendrites in a tangential course. At a deeper level there are somewhat larger cells whose dendrites spread out in all directions. Still another type of cell may be found having long dendrites passing over the greater part of the distance between ependyma and outer surface.

The cerebellum has a structure which appears to foreshadow in its general plan the details of structure of a higher brain. It has a series of well defined layers, and the same layers are present in the same relations to each other as are found in the human cerebellum. There is a wide nuclear zone lying next the ependyma. A molecular layer lies next the outer surface. Between the two there is a crowded row of Purkinje cells. These cells have the familiar dendrites forming an arborization in the outer zone, but the degree of branching of the dendrites is far less marked than in the mammalian cerebellum.

The medulla oblongata exhibits a most beautifully reticulated system of fiber tracts. In this reticulum the microscope reveals neuroglia cells, processes of ependyma cells, and an occasional nerve cell. Whether the nerve cells are present except in connection with the nuclei of the cranial nerves which arise here is a fact which I have not yet determined.

Summarizing the above results, we see that mid-brain, cerebellum, and medulla oblongata foreshadow in organization the human type; but that the fore-brain does not. Coupling this fact with the suggestion to which I have already alluded as to the significance of the dorsal eminences of the fore-brain, and we have grounds for the hypothesis that the cerebral cortex proper is of secondary development.

SOME MANITOBA CLADOCERA, WITH DESCRIPTION OF ONE NEW SPECIES.

BY L. S. ROSS.

No record is to be found among the literature upon Entomostraca, of any systematic work done upon this interesting division of the Crustacea in Manitoba, or any of the provinces of Canada. The region is yet open to the student of the distribution of the group. A short stay in the province of Manitoba in June, 1895, was utilized by the author in making a few collections from the region about Portage la Prairie on the Canadian Pacific railroad, fifty-five miles west of Winnipeg. Before leaving the province some vials of alcohol were left with a resident of the town to be filled with collections. A vial was received every second week from the time of the visit until cold weather, the latest being filled October 21, 1895. One vial remained to be filled the following spring.

Collections were taken by the author from the Assiniboin river, from a deep, weedy slough which was once the channel of the Assiniboin river, from railroad ditches, and from prairie sloughs and ponds. A hurried visit to Lake Manitoba gave opportunity for a few hauls of the net among the rushes along the shore.

An examination of the material obtained shows the presence of thirty species and varieties, one of which, and possibly two, is a new addition to the list of described species.

The forms found belong to the following families:

Sididæ	1
Daphniidæ	9
Bosminidæ	1
Macrothricidæ	4
Lynceidæ	13
Polyphemidæ	1
Leptodoridæ	1
Total	30

The distribution of the species is given in the following table:

ASSINIBOIN RIVER.

Daphnia pulex De Geer.
Ceriodaphnia consors (?) Birge.
Iliocryptus sp ?
Chydorus sphæricus O F. Muller.
Graptoleberis testudinaria var. inermis; Birge.

RAT CREEK AT M'DONNELL ON PORTAGE PLAINS.

Daphnia pulex De Geer.
Ceriodaphnia consors (?) Birge.
Simocephalus vetulus O. F. Muller.
Simocephalus serrulatus Koch.
Scapholeberis angulata Herrick.
Scapholeberis mucronata O. F. Muller.
Eurycercus lamellatus O. F. Muller.
Alona costata Sars.
Graptoleberis testudinaria var. inermis, Birge.
Pleuroxus procurvus Birge.
Pleuroxus excisus Fischer.
Pleuroxus sp ?
Chydorus sphæricus O. F. Muller.
Acroperus leucocephalus Koch.
Polyphemus pediculus Linn.

PRAIRIE SLOUGH NEAR PORTAGE LA PRAIRIE.

Daphnia pulex var. pulicaria, Forbes.
Ceriodaphnia consors (?) Birge.
Simocephalus vetulus O. F. Muller.
Simocephlus serrulatus Koch.
Scapholeberis mucronata O. F. Muller.
Lathonura rectirostris O. F. Muller.
Macrothrix laticornis Jurine.
Bunops scutifrons Birge.
Eurycercus lamellatus O. F. Muller.
Graptoleberis testudinaria var. inermis, Birge.
Dunhevedia setiger Birge.
Pleuroxus denticulatus Birge.
Pleuroxus procurvus Birge.
Pleuroxus sp ?
Chydorus globosus Baird.
Chydorus sphæricus O. F. Muller.
Alonopsis latissima var. medir, Birge.
Acroperus leucocephalus Koch.
Polyphemus pediculus Koch.

DEEP WEEDY SLOUGH AT PORTAGE LA PRAIRIE.

Sida crystallina P. E. Muller.
Daphnia pulex DeGeer.

Ceriodaphnia consors (?) Birge.
Ceriodaphnia reticulata Jurine.
Ceriodaphnia acanthinus n. sp.
Simocephalus vetulus O. F. Muller.
Scapholeberis mucronata O. F. Muller.
Lathonura rectirostris O. F. Muller.
Bosmina longirostris O. F. Muller.
Eurycercus lamellatus O. F. Muller.
Alona quadrangularus O. F. Muller.
Pleuroxus denticulatus Birge.
Pleuroxus procurvus Birge.
Chydorus sphæricus O. F. Muller.
Camptocercus rectirostris Schoedler.
Polyphemus pediculus Linn.

LAKE MANITOBA.

Bosmina longirostris O. F. Muller.
Chydorus sphæricus O. F. Muller.
Leptodora hyaulina Lilljeborg.

CERIODAPHNIA ACANTHINUS, N. SP.

The body is large, round, with the valves of the shell forming a well developed posterior spine. The head is separated from the body by a very deep depression. Head is low, small, rounded in front of the eye, sinuous above and angled between the eye and the antennules; the lower margin is nearly in a line with the lower margin of the valves of the shell.

The shell is very strongly reticulated with small, very sharply-marked hexagonal reticulations measuring about .016 to .021 mm. across. Small sharp spines project from the angles of the reticulations, many at nearly right angles with the surface of the shell. In the possession of these spines this species closely resembles C. setosa, Matile. No spines were seen on the rounded front of the head as are usually present in C. lacustris, Birge. The dorsal margin of the shell is arched, curving gradually into the posterior margin.

The posterior spine of the shell may be near the dorsal margin, or one-third the distance from the dorsal to the ventral margin. When the spine is situated low the posterior shell margin above is slightly concave. The spine is as well developed as in C. lacustris, Birge, and often ends in blunt teeth, but is not divided into two parts at the end as is sometimes the case in that species. The posterior margin of the shell curves gradually into the strongly convex ventral margin. The fornices are greatly developed, extending almost the width of the shell. They are almost as broad but are not so sharply angled as in C. lacustris, and do not end in sharp teeth.

The antennules are short and thick, reaching to or a very little beyond the angle behind the eye. Setæ are present toward the distal end. The antennæ are long and rather slender; the setæ reach nearly to the posterior margin of the shell.

The post abdomen is of moderate size, slightly tapering toward the end and is armed with nine to eleven strong recurved spines of nearly equal size, except the first and last, which are smaller. The anal claws are long,

curved, and denticulate on the inner side with minute teeth of two sizes. The teeth of the basal two-fifths of the claw, some forty or fifty in number, are two or more times longer than those of the distal portion.

The eye is of moderate size, situated near the margin of the head or back a short distance from the margin. The lenses do not project far from the eye pigment. The pigment fleck is small, rounded, and situated above the posterior portion of the eye at a distance approximating half the diameter of the eye.

In general shape the species resembles C. rotunda, Straus. The posterior spine is not as near the dorsal margin as Kurtz figures it in C. rotunda, but is in nearly the same position as in a specimen examined of that species identified by G. O. Sars of Norway. The reticulations are as distinct and the double contoured markings (due merely to depth of reticulated areas) mentioned by Herrick and used in his key, are fully as prominent as in C. rotunda.

The reticulations and the minute spines on the surface of shell are very like those described and figured in C. setosa by Matile. The measurements of C. setosa are but little over half those of C. acanthinus. Matile's description of C. setosa gives the length .42 to .54 mm. and the height .27 to .36 mm., while C. acanthinus measures from .80 to 1. mm. in length, and .70 to .77 mm. in height. The head of C. acanthinus is larger and extends nearer to a level with the ventral margin of the shell. Some specimens of C. reticulata taken from the same slough at the same time have the reticulations nearly as distinct as in C. acanthinus, and also possess minute spines upon the surface of the shell. The two species are distinct, however, because of differences in the shape of the body, and of the difference in the armature of the anal claws.

The males were not seen. The mature females measure from .80 to 1. mm. long and .70 to .77 mm. high. Found in abundance in a weedy slough in late May, 1896, at Portage la Prairie.

NOTES ON SOME OF THE SPECIES.

Sida crystallina.—Was taken only from a deep weedy slough at Portage la Prairie.

Ceriodaphnia reticulata.—Was in a bottle sent in May, 1896, from the slough at Portage la Prairie. The specimens have the reticulations very sharply marked. Some show numerous short spines at the angles of the reticulations. The number of spines on the anal claw varies somewhat. This species was found with C. acanthinus. It differs from the typical C. reticulata in the distinctness of the reticulations and in the presence of spines on the shell in some individuals.

Ceriodaphnia consors.—Numerous specimens were found at various places which are with much hesitation referred to this species.

Scapholeberis angulata.—Was taken only in small numbers, a few being found in Rat Creek on Portage Plains.

Daphnia pulex var. *pulicaria* —Was found in small numbers in a prairie slough near Portage la Prairie.

Simocephalus daphnoides (?).—The body is robust, with greatest height a little behind the middle. The head is rounded in front and has no spines. Lower margin of the head is slightly concave, straight, or even slightly convex to the base of the short beak which may project at nearly a right angle to the lower margin of the head. The head is separated from the body by only a very slight depression. Depth of the head in one specimen is .77 mm., length from the posterior margin of the base of the antennæ .52 mm. The head has a daphnia-like appearance. The ventral margin of the shell has few very short blunt teeth. The posterior margin from short blunt posterior spine toward dorsal margin has teeth better developed than those on the ventral margin. The dorsal margin teeth continue forward a short distance. The posterior spine is very short, blunt, armed with short teeth and is situated little above the middle of the posterior margin.

The eye is of moderate size, situated near the front of the head, or at a short distance from the front, and at a distance from the lower margin equalling one-half the diameter of eye, or at a distance slightly greater than diameter. Pigment fleck is irregular in shape; elongated, rhomboidal and oval forms were seen, Pigment fleck is small, situated near the posterior margin of the head.

Specimens measured vary in length from 2.04 mm. to 2.53 mm. in depth from 1.20 mm. to 2.04 mm.

The description of S. daphnoides as given by Herrick in American Naturalist, May, 1883, and in Entomostraca of Minnesota, is rather brief. Herrick states that the form is found only south of the Tennessee river; but a comparison of specimens taken in Manitoba, with the original drawings and brief description in the American Naturalist, makes it probable the form is found even in that northern province.

Lilljeborg's "Crustaceis" published in 1853, gives drawings of S. vetulus, with the lower margin of the head as nearly straight as in the figures by Herrick, and the general outline of the body almost as daphnia-like in appearance.

Eylmann in the "Berichte der Naturforschenden Gesellschaft zu Freiburg" Zweiter Band, Drittes Heft, published in 1886, figures the lower margin of the head of S. vetulus straight to the short beak, and the body with greatest height at the middle.

A specimen of S. vetulus identified by G. O. Sars of Norway, and examined by the author, has the lower margin of the head straight to the very short beak, and the eye situated at a distance from the lower margin, equal to about one-half the diameter of the eye.

Herrick says in his description that the curved spines present in the other species at the caudo-ventral angle of the shell are absent from S. daphnoides. If this be constant it seems to be the only character not possessed by S. vetulus.

The specimens taken in Manitoba, and also in Iowa, vary in size and shape of the head and of the body,—there are such grades of variation, and authors figure such differences of form in S. vetulus that it seems very probable that S. daphnoides is merely an extreme form of S. vetulus.

Bosmina longirostris.—Found in only two collections: one from Lake Manitoba and the other from a slough at Portage la Prairie.

Macrothrix laticornis.—This species was met with only in a shallow prairie slough, and was by no means abundant.

Bunops scutifrons.—This beautiful species was found rather frequent in the shallow prairie slough at Portage la Prairie.

Iliocryptus sp?—A few shells and one individual of this genus were taken from the Assiniboin river. The species is probably longiremis, Sars.

Alona quadrangularis; Alona costata.—There is some question as to the identification of these two species. Only a single individual of each was found. The specimen that may be Alona costata is not strongly striated, but other characteristics agree with descriptions of this species.

Graptoleberis testudinaria var. *inermis.*—Although taken at three different places this species was rare. A few individuals were found in Rat creek, one in the collection from the Assiniboin river, and one individual, and a few shells from a prairie slough.

Dunhevedia setiger.—This species is apparently rare during the season of the year the collections were taken, as few individuals were found. They were taken from a prairie slough. Birge, in his "List of Crustacea Cladocera from Madison, Wisconsin," mentions the fact of D. setiger being one of the rarest of Cladocera in that region, but that in the month of August he found them in immense numbers, both males and females.

Pleuroxus sp ?.—The shell is long and low, in some specimens evenly arched from the posterior dorsal angle to a point a little in front of the brood chamber, from which the curve is flattened slightly to a distance including the basal third of the long sharp rostrum. In others the dorsal margin is evenly arched from the postero-dorsal angle to the rostrum. The head is small, high, with the long, sharp, curved rostrum far from the anterior margin of the shell, parallel with it, and reaching nearly to a line with the ventral margin of the shell. The ventral margin is straight for two-thirds of its length from the anterior margin; the remaining third curves gently upward and has a single small tooth pointing backward, a little in front of the sharp curve into the posterior margin. The ventral margin has long pectinated setæ, becoming shorter toward the posterior end of the shell. The anterior margin has setæ for a short distance from the ventral margin. A blunt posteriorly directed projection is formed by the postero-dorsal angle of the shell.

The post abdomen is long, slender, truncate, tapering toward the end. The posterior edge is slightly concave, and is armed with eighteen to twenty or more small spines; the spines at the distal end of the series are much the longer and stronger. Anal claws are pectinated, long, and slightly curved. The second basal spine is longer than the first.

The eye is of moderate size. Pigment fleck is about one-half as large as the eye, and is situated one-fourth the distance from the eye to the end of the rostrum. The antennules are cylindrical, with setæ at the end, and a lateral seta. Length of antennules about equals the distance between the eye and the pigment fleck. Antennæ are short, small, with long setæ.

The specimens do not agree in all respects with the description given by Birge of Pleuroxus gracilis var. unidens, but do agree in many points. The largest specimen found measures .60 mm. in length by .38 mm. in height; another measures .60 mm. long and .33 mm. high. Birge gives a measurement of .85 mm. by .46 mm., and states that the species is the largest yet seen. The original description of P. gracilis var. unidens states that, "the striation is very plainly marked." The specimens found by the author are only very faintly striated, and that most distinctly at the anterior part of the shell, where the lines of striation are approximately parallel to the anterior margin. The larger part of the surface is free from markings, either striation or reticulation as far as could be observed. The

shell is more arched dorsally than P. gracilis is figured by Matile. Birge's description of P. gracilis var. unidens says: "The upper posterior angle is prolonged into a projection, quite characteristic, seen, I believe, in no other species." In the specimens found there is a slight projection at the angle, but not so pronounced as figured by Birge and by Herrick. The lower posterior corner is rounded and has a small tooth anterior to it as in P. gracilis var. unidens.

It seems improbable that the differences between the specimens and the description and drawings of P. gracilis var. unidens should fall within the range of variation of a variety. The males were not seen. Collected in small numbers in June, 1895, from a shallow slough and a small creek.

Pleuroxus excisus.—Only one or two individuals were observed. These were taken from Rat creek, a sluggish stream flowing into Lake Manitoba.

Alonopsis latissima var. *media*.—The specimens resemble the species described by Birge, but have some points of difference. Birge's descriptiou is as follows: "Rostrum prolonged, and shell sharp, somewhat quadrangular in shape, marked by striæ. The dorsal margin is convex, the hinder margin nearly straight. Its lower angle is rounded and without teeth. The lower margin is concave and has long plumose setæ. The front margin is strongly convex. The post abdomen is long and slender, resembling that of Camptocercus, and is notched at the distal extremity; it has two rows of fine teeth and some fine scales above them. The terminal claws are long, slender, with a basal spine in the middle, and are serrated. The antennules are long and slender, but do not reach to the end of the rostrum. They have each a flagellum and sense hairs. The antennæ are small and have eight ($\frac{3\,0\,0}{3\,1\,1}$) setæ and two ($\frac{1\,0\,0}{1\,0\,0}$) spines. The labrum resembles that of A. leucocephalus, but is slightly prolonged at the apex. The intestine, cæcum, and color resemble those of Acroperus. There is a trace of a keel present on the back."

Herrick's statement, in part, is as follows: "The specimens seen in Minnesota resemble this species [A. latissima var. media] very nearly, apparently, but there are some differences. The terminal claw has an increasing series of spines to the middle; there seems to be no lateral row of scales beside the anal teeth; the abdomen is rather broad at the base and narrows toward the end. The shell is not square behind. The

lower margin has a few long hairs anteriorly which are followed by a series of teeth, and in the concave part a somewhat longer set to a point just before the lower curved angle."

In most respects the Manitoba specimens agree more nearly with Herrick's description than with Birge's. A few points of difference are noted. In the Manitoba specimens a few long hairs are present on the lower margin anteriorly, then at a little distance posteriorly from the hairs are short, sharp bristles, hardly heavy enough to be called teeth, becoming largest on the concave part of the margin. In one specimen the end of the abdomen is deeply cleft, the posterior lobe bearing four very strong teeth of nearly equal size. Herrick says that hexagonal reticulations are seen upon the shell of the embryo yet in the brood sac. In several sexually mature females observed faint reticulations are present, more distinctly seen near the ventral margin.

Polyphemus pediculus.—This species was found to be quite common in the Portage Plains region. It has not been reported from Iowa. Although reported from Georgia it seems to be more commonly found in the north.

A NEW SPECIES OF DAPHNIA, AND BRIEF NOTES ON OTHER CLADOCERA OF IOWA.

BY L. S. ROSS.

A few collections taken from West and East Okoboji Lakes and Spirit lake in June, and from the sloughs of the Des Moines river in the fall of 1896, have added six more species to the list of Cladocera in the state, as given in the "Proceedings" of the Academy for 1895. Five of the species are common to the country, and one is an hitherto undescribed species of Daphnia. A few individuals of a form of the difficult genus Bosmina were found which may be the young of Bosmina longirostris, O. F. Muller. If not the young of this species then seven instead of six species will be added to the list.

The species taken the past summer and fall not reported in the "Preliminary Notes" are:

Daphnia pulex De Geer.
Daphnia hybus n. sp.
Bosmina longirostris O. F. Muller.

Pleuroxus exiguus Lilljeborg.
Alona guttata Sars.
Graptoleberis testudinaris var. inernis, Birge.

This gives a total list of thirty-one species of Cladocera reported from the state.

DESCRIPTION OF A NEW SPECIES—DAPHNIA HYBUS.

The body is large, robust, with a prominent keel-shaped projection on the dorsal margin immediately anterior to the brood chamber; the projection rises at a rather low angle anteriorly, approximately 20 to 25 degrees, but falls posteriorly at a greater angle, approximately 40 to 50 degrees. It is present on the ephippial females and also on those bearing summer eggs. The measurement of the projection on one specimen gave the length of .14 mm. and a height of .05 mm. On one specimen a second projection is present, located on the dorsal margin above the base of the antennæ. Measurement showed its length to be .28 mm. and height, .09 mm. In yet another specimen the projection above the base of the antennæ is evident under the shell, and it would apparently have become external at the next moult. The dorsal margin of the shell is convex, minutely spined from the posterior shell spine nearly to the front of the brood chamber. In one or two specimens the spines were not observed. The ventral margin is strongly convex, and is armed with small spines about one-half the distance forward from the posterior shell spine; the margin is sinuous below the posterior spine, which is situated usually about half way between the median line of the body and the dorsal margin, but sometimes nearly on the median line. Spine is straight, slender, directed slightly upward, .77 mm. long in one specimen, and has scattering, feeble spinules.

The head is broad, not helmeted, strongly arched dorsally, and is not separated from the body by a depression. The ventral margin of the head is slightly concave below the eye, midway between the front of the head and the end of the long beak. Depth of the head is about two times the length from the base of the antennæ.

The eye is of medium size, with few prominent crystalline lenses, and is situated at a distance from the front of the head, about equal to the diameter of the pigmented portion. Distance of the eye from the posterior margin of the head is little greater than diameter of the eye. The transparent orbit reaches to the front of the head. Pigment fleck is small, not

more than one-fourth the diameter of a crystalline lens. It is situated near the median line, about midway between lower half of eye and the posterior margin of the head.

The antennæ are moderately developed, the setæ reaching nearly to the posterior margin of the shell. The first joint of the setæ is longer than the second.

The post abdomen is rather slender, tapering toward the posterior end, and is armed with about fifteen strong curved spines, which become gradually smaller anteriorly. Anal claws are pectinated, and armed with a strongly developed basal comb of two groups of spines of about six in each group. Spines of upper group much smaller than those of lower. Processes of the post abdomen are separate, first longest, not haired, second and third haired.

Some measurements are as follows:

Length	2.30 mm.	Height	1.32 mm.
Length	2.00 mm.	Height	1.27 mm.
Length	2.77 mm.	Height	1.85 mm.
Depth of head	1.00 mm.	Length of head	.46 mm.
Depth of head	1.07 mm.	Length of head	.50 mm.
Depth of head	.88 mm.	Length of head	.44 mm.
Posterior spine, .70 mm. to .77 mm.			

The species is evidently very closely related to D. minnehaha, Herrick, and may have only varietal rank.

The general outline of the body of old females is similar to that of D. minnehaha, including the angle or projection in front of the brood chamber. None of the specimens examined showed any evidence of teeth upon the dorsal angle as are present in males and young females of D. minnehaha. No broad projection on the dorsal margin above the base of the antennæ is mentioned in descriptions of D. minnehaha or figured in the drawings. The beak is longer in D. hybus, and is slightly curved toward the end. The eye in D. hybus is farther from the front margin of the head, and the lenses much larger than are figured in D. minnehaha. The posterior spine is longer in D. hybus. In D. minnehaha "the anal spines are eleven or more in full grown females, and decrease only moderately upward." In D. hybus the anal spines vary from about fifteen to nineteen. Herrick says of D. minnehaha: "The size is small but variable; 1.8 mm. is a common measurement." In addition the following measurements are given: "Female, length, 1.44 mm.; spine, .33 mm.; head, .26 mm.; depth of

head, .46 mm. Ephippial female, length, 1.64 mm.; spine, .20 mm.; head, .35 mm.; depth of head, .80 mm.; greatest depth of shell, .94 mm."

A comparison with the measurements given of D. hybus shows the latter to be a much larger form, in some instances approaching a length and depth double that of D. minnehaha.

In the "Preliminary Notes on the Iowa Entomostraca," published in the proceedings of the Iowa Academy of Sciences, vol. III, I followed the classification of Birge and Herrick, and placed Daphnia retrocurva, Forbes, in the list as a variety of Daphnia kalbergiensis, Schoedler. At that time I had not seen the original description of either species.

In Forbes' description of D. retrocurva first published in the American Naturalist, vol. XVI, page 642, August, 1882, he says: "The shell is reticulate and its spine long and straight, there is no macula nigra, and the caudal claws have a row of teeth at their base." The row of teeth referred to is the accessory comb. The teeth of the comb are often very small and hard to distinguish, but in all the specimens of D. retrocurva I have examined they are present. In "Die Cladoceren des Frischen Haffs," published in 1886, Schoedler gives his original description of D. kalbergiensis under the name Hyalodaphnia kalbergiensis. The statement in regard to an accessory comb is: "Die Schwanzklauen sind ohne secundare Zähnelung."

The presence or absence of the accessory comb is recognized by systematists as a specific character. Hence D. retrocurva cannot be ranked as a variety of D. kalbergiensis but as a distinct species. In his "Notes on Cladocera Crustacea at Madison, Wis.," Birge suggests the propriety of separating the American forms from the European D. kalbergiensis, because of the pectinated caudal claw, and says: "This would probably bear the name D. keruses, Cox."

The note by Cox in the American Monthly Microscopical Journal of May, 1883, in which the name of D. keruses is proposed for this remarkable form is an incomplete description and the illustration is not accurate. The description of the species with the proposed name D. retrocurva was published in August of the preceding year.

It is evident that the form described under the names D. retrocurva and D. keruses is not a variety of D. kalbergiensis, but is species D. retrocurva, Forbes, of which D. keruses, Cox, is a synonym.

NOTE.—Since writing the above upon D. retrocurva the "Revision of the Genus Daphnia," by Jules Richard of Paris, has been published, in which D. retrocurva is recognized as a species because of pigment-spot and caudal claw characters, and D. keruses as a synonym of it.

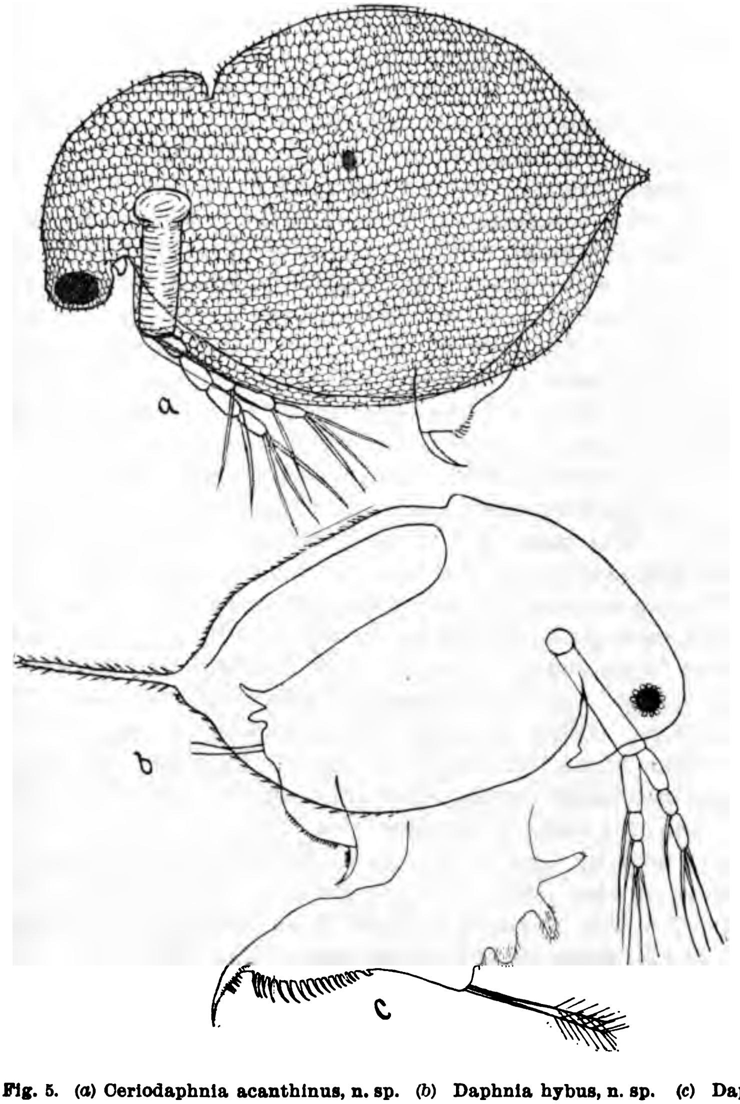


Fig. 5. (*a*) Ceriodaphnia acanthinus, n. sp. (*b*) Daphnia hybus, n. sp. (*c*) Daphnia hybus, post abdomen.

NOTE—The reticulations in *a* are somewhat too regular.

THE ILLINOIS BIOLOGICAL STATION.

BY L. S. ROSS.

In Europe there are twenty-seven or more marine biological stations, one in Japan and five in the United States. The attention of biologists has been given mostly to the study of marine life, but some of the inland scientists are taking to the fresh water, leaving the marine life to be salted down by those near at hand. But it is only of late years that a few zoologists have bethought themselves to halt in their rush to the marine stations and cast a microscopic squint at the myriads of forms dashing and crowding through the water of the lakes and streams, and even inviting the hauls of a net in order to relieve the pressure of an overabundant surplus of population.

Germany possesses two fresh water biological stations, one on Lake Plön in the northern part of the country, and the other upon Müggle lake, near Berlin. There is one station in France and a peripatetic one in Bohemia. The Allis private laboratory at Milwaukee was the first fresh water station in this country. The University of Minnesota had for several years a summer station at Gull lake, and for the past two years the University of Indiana has maintained a summer school of biology at Turkey Lake. The Michigan Fish Commission and the University of Michigan have been studying the waters of the state for several years with special reference to fish culture.

The station established at Havana, Ill., on the Illinois river, is the first fresh water university biological station with adequate equipment and working force in the country, and is the only station in the world having as its subject of investigation the life of a river system. The region about Havana has long been noted as a sportsman's paradise because of the wide bottom lands of the river and the many sloughs and swamps; and it has proved to be equally the paradise of hunters of water fleas and the like more minute game than water fowl. The amount of microscopic animal life of the water is much more

in individuals than in any other water in the world examined to determine quantity. And the number of forms of life is nearly twice as great as that in an equal amount of water from the great lakes or from the lakes of northern Germany.

The station is located at the foot of Quiver lake, a sheet of water separated from the channel of the river by a low bar, about two miles up the river from Havana. A rented house-boat was used for two years from the time the station was opened in the spring of 1894. Last spring the laboratory was moved into a new boat specially designed and built for the station at a cost of $1,260. The new boat has a deck 20 by 60 feet, on which is a cabin 16 by 56 feet, divided into an office for the laboratory staff, a main laboratory with a long tank and sink, shelves and tables for fifteen students, and a small kitchen. The laboratory equipment includes microscopes, reagents, etc., necessary for microscopic work; nets, dredges and seines for collecting, and working libraries. Three or four row boats belonging to the station are at the disposal of the workers. Besides these the station owns a 25-foot steam launch licensed to carry seventeen persons.

One of the lines of work receiving especial attention is the determination of the plankton of the river, that work being done by the superintendent of the station. Besides the principal station there are seven sub-stations where the plankton is taken at stated intervals through the year. To collect the plankton a certain amount of water is pumped into a net of the finest silk; then careful determination of the quantity, species, and even numbers follows the collecting.

The station has received for its support during the past two years the sum of $10,400 from the following sources:

Appropriation April, 1894, from the University of Illinois	$ 1,800
Appropriation by last legislature for two years, expiring July 1, 1897: Equipment	2,500
Running expenses, $3,000 per year	6,000
Income from fees	100
Total	$ 10,400

Only a small number of students can be accommodated at present, but it is the earnest desire of the director, Dr. S. A. Forbes, to enlarge the facilities sufficiently to establish a summer school of biology for the teachers of the secondary schools of the state.

Is it not possible for Iowa to organize and conduct a station similar to that supported by the state of Illinois? Perhaps a

thorough investigation of the situation, and careful thought, might suggest some plan more feasible for our state than that followed in our sister state. Illinois has a state laboratory of natural history that is studying the life of the state. We have no such authorized laboratory. But we have our State university, our Agricultural college, and other colleges broadcast over the state whose scientists are interested in biological problems, and who would certainly agree that the study of the life in our own lakes and streams, and the solving of oecological problems of our own fauna and flora are of paramount importance. Some work is being done along these lines by members of the teaching forces of the various schools. But more wide-reaching and better results could be obtained by organized effort. The life of our lakes and streams is comparatively unknown.

Such a station could be made of great value to the educational interests of the state. Provision could be made for a summer school of biology, where students could study our common every day forms of life in the midst of their activities. Not all in regard to an animal or plant is learned by cutting up an alcoholic specimen. The station should have a course of study so arranged that a student from any college in the state upon taking it would receive credit for it as actual college work. If he is far enough advanced to conduct original investigations let him receive credit for work done. Another course should be arranged that would bring the station more closely in touch with the broad educational interests of the state; that is, a course for the benefit of the public school teachers, a course supplying more directly the needs of science teachers over the whole state.

If the colleges of the state would combine in agreeing to accept work done by their students at the station during the summer under competent direction, as college work, it would encourage some to accept of facilities which may now be beyond their reach. And the colleges might do more; some might equip and support a table at the station for the most worthy students desiring to take advantage of the opportunity.

The scientific and educational possibilities of such a station are many. If financial possibilities were as many and as bright as the educational, then a biological station in Iowa would be easy to found. But how could it be founded and maintained without money? And under the control of what body should

it be? These are questions harder to answer. The first, however, is really not hard to answer. Financial support is a necessity first and other things follow. Much valuable work may be done without very expensive apparatus, but all apparatus costs something. Perhaps there is no method but that of appealing to the state to lay the foundation by an appropriation, then perhaps some of the superstructure could be erected from fees. As an answer to the second question, regarding the control of the station, one that offers itself is that the State Academy of Sciences should have control by whatever means seemed most desirable.

NOTE ON PROBABLE LIFE HISTORY OF CREPIDODERA (EPITRIX) CUCUMERIS, HAM.

BY F. A SIRRINE.

During the winter of 1894 and 1895 a trouble known as "Pimply potatoes," among potato growers, was brought to our attention. As the trouble appeared to be some skin disease, it was turned over to Mr. F. C. Stewart, the mycologist. At the time he came to no definite conclusion as to what the trouble might be. Early in the fall of 1895 Mr. Stewart obtained a quantity of "Pimply potatoes" for microscopic examination. It was found that the pimples covered what appeared to be a brown "sliver" in the flesh of the potato. This "sliver" proved to be a tube lined with broken starchless cells, the starch grains usually occurring free within the tube. Our natural conclusion was that the trouble was caused by the puncture of some insect and that the pimple resulted as an effort of the growing potato to heal the puncture. No trace of castings could be found within the tube, hence it appeared that the tube was not the result of larval mining, nor could it have been made for the deposition of an egg, for in such a case the tube would have shown larval castings. Thus it appeared as if the puncture must be the work of some "snout beetle," or of some hemipterous insect.

A close watch for the depredator was maintained during the past summer. I had my eye on the adult of a new seed stalk weevil *Centorhynchus seriesetosus* Dietz, of kale, turnip and cabbage.

On July 7th Mr. Stewart found a small thread-like white worm, about one-sixth of an inch long, burrowing into potatoes. He also found small white bodies in the soil around the potatoes. The white bodies were found to be pupæ of some of the flea beetles. They were bred, issuing in about eight days as adult *Crepidodera cucumeris.* About two weeks after the grubs were found mining the potatoes they issued as adult beetles and proved to be *Crepidodera cucumeris.*

There is a leaning to the theory that the potato flea-beetle is double brooded in this section, Long Island. I think that this is based on the fact that the beetles appear quite numerous in April and early in May on plantain and various other weeds. I have seen no evidence of their pairing at this season —in fact they were not observed pairing until June. Furthermore they were very destructive to potato and tomato vines the past season from the time the plants came up until the middle of June, at which time the beetles commenced to diminish in numbers. From the middle of July until August they appeared again in such numbers that they soon made the potato fields appear as if a hot wind had struck them.

A close watch was kept for signs of another brood after the July brood. No signs of pairing were noticed. The adult beetles appeared to gradually disappear, until late in October scarcely a single beetle could be found.

As the facts stand there is probably but one brood of the potato flea-beetle a year. The eggs are probably dropped during the month of June to the ground from whatever plant the adults are feeding upon. The larva hatch and work their way to the roots and tubers of the plants upon which they feed. The pupa stage is passed in a naked state in the surrounding soil. The adults issue in July and August, feeding awhile, then scatter to hibernate. They come out early the following spring, feed on various plants until the latter part of May, or until June, at which time they begin to pair and deposit their eggs.

The larvæ are only about one-sixth of an inch long. They are provided with three pairs of true legs and a single anal leg. They have a peculiar habit of resting at nearly right angles to the object on which they are feeding. They will remain in this position even after the root or tuber upon which they are feeding has been removed from the ground. They rarely mine more than the length of the body into the root or tuber. These

mines are barely large enough to more than admit of the larva getting into them—in fact it requires considerable effort on the part of the larva to back out of one of these mines, when disturbed.

It was found that some varieties of potatoes contained more pimples than other varieties. It was also found that varieties which did not contain many "pimples" often contained as many "slivers" or tubes as the more "pimply" varieties. At the same time potatoes in all varieties could be found with "slivers" where no pimples had been formed. Whether "pimples" are formed only at certain stages of growth of the potato, or whether some varieties form "pimples" while others do not, is still a question.

CONTRIBUTIONS TO THE HEMIPTEROUS FAUNA OF IOWA.

BY HERBERT OSBORN AND E. D. BALL.

I. ON THE LIFE-HISTORY OF JASSIDÆ.

(With descriptions of new species and a review of the genus Deltccephalus.)

In various papers published during the past five years the senior author has called attention to the injuries caused in grass lands and pastures by the numerous species of Jassidæ, which swarm, often by millions to the acre, upon various species of grasses.

In these papers it has been shown that the loss, though seldom noticed, must be really enormous, and that by the use of the tar pan or "hopper-dozer" the insects may be to a great extent destroyed. Further than this, however, our knowledge has been too meager to furnish a certain basis for remedial measures. It is true studies were made of a few species and some facts learned as to their life-history which warranted the belief that burning, mowing, etc., might be of service, but still so much remained unknown regarding even the most common species, that there seemed a necessity for a more exhaustive study. At the beginning of the present season (1896) a study was planned, the essential features of which were: First, a determination of the life histories of as many as possible of the species known to feed upon grasses. Second, the determination of the range of

the food plants for each species, especially in the larval stages. Third, the collection of all species occurring on grasses and their careful identification with a close study of the specific limits of each, as a basis for further life history studies.

Any facts suggestive of successful treatment have been carefully noted, and suggestions as to treatment of individual species made, but it has been deemed essential in this study to hold in reserve general conclusions as to treatment and to gather, first, all facts possible bearing on the life and habits of the species. These will undoubtedly furnish a scientific basis for economic treatment.

Insectary studies have consisted in rearing, as far as possible, all species in breeding cages, consisting of glass globes or netted frames over grass in large pots, along with continuous field study, the one as check to the other. In the investigation some sixty species have come under observation as grass feeders, not to mention some sixty more referred to other food plants, and their study has involved the examination of many thousands of individuals in all stages

Of a number of species we are able to present sufficient details of life history to warrant positive conclusions, while of others the record is yet too fragmentary to be more than a starting point for future work.

While this study was undertaken primarily with reference to its economic aspects, and this phase has been dealt with particularly in a paper, duplicating this in part, to be published in bulletin 34 of the Iowa experiment station, so much matter of a technical nature has been accumulated which seems of importance in the systematic study of this group that it has been deemed desirable to publish it, with full technical descriptions of new species, where it will reach students of systematic entomology, and those interested in the biological questions discussed.

We have as a basis for work in this group, aside from the large mass of material collected in Iowa, types of all the Homoptera described by Mr. E. P. VanDuzee as well as the entire collection of Hemiptera which he made, and which formed the basis for his numerous contributions to American Hemipterology.

The college collections contain, further, a large amount of material in Hemiptera from Colorado, South Carolina and Georgia collected by Morrison; from New Mexico, Arizona, California and the northwest, collected by Wickham; from Mexico, collected by Osborn and Townsend, besides numerous smaller series received in exchange or for determination. Also series of European species, embracing representatives of a large proportion of the genera. Also some exotic material from the Bahamas, West Indies, etc.

. The plates are photo-reproductions of drawings made by Miss Charlotte M. King, under personal direction and supervision of the authors.

It has not been our purpose to prepare a full list of species, but only to include such as we have studied. We have followed in arrangement, however, the "Catalogue of Jassoides," by Mr. E. P. VanDuzee, and that catalogue may be consulted for additional references, synonomy and bibliography.

Types of the new species are deposited in the National museum.

Some of the results which seem to be general in nature may be mentioned here.

The species of Jassidæ have, as a rule, a decided limitation as to food plant, usually holding closely to one species of plant, almost invariably limited to one plant for breeding, but feeding more indiscriminately in maturer stages.

So far as known, all the species deposit eggs upon the stems under the leaf sheaths or in the leaves of the plants used as food.

There is a wide difference in life-histories, some having one brood, the majority of the grass-feeding species two, and still others three in a season, and the successive stages occurring at widely different times.

Except in the case of adult hibernation the ordinary life of a brood of adults does not exceed two months, and for the individuals of a brood rarely over one. The males appear a week to ten days before the females and disappear as much earlier. In general, one brood of adults will have disappeared before the larvæ of the next have matured, so that individuals collected at any time may be referred with assurance to a particular brood.

It follows also that eggs for each brood are deposited within a limited time and that a period may be defined during which all eggs of a given brood for a given species will have been deposited, and during which time measures for their destruction may be applied.

Observations were made to ascertain whether simply cutting the grass and leaving it in the field would prevent hatching, and in no case were eggs observed to hatch from stems cut green. Part of the stems from a plant in which eggs were fully developed were cut and left to dry. The second day after the eggs hatched in the uncut stems but no larvæ issued from those that were cut and, on examination, the eggs were found to be crushed and distorted from the shrinking of the plant tissues and by the curling of the edges of the sheaths in drying. Even if hatched they would have been unable to escape from the rigid incurved edge.

It has been learned that the larvæ present definite characters which are of specific, and in some cases generic, value. These, along with what prove to be constant characters in large series of adults, enable us to combine some forms hitherto considered

as distinct species, and also to separate as distinct some forms hitherto included with other known species.

Colorational characters in certain genera are of very little value, since it is found that summer broods and species occurring in shaded localities are pallid or unicolorous, while autumn broods or exposed individuals assume darker and more definite markings, often varying to black.

Another feature of considerable interest and of value in the discrimination of species is presented in the fact that for a number of species there are distinct long and short winged forms with consequent variations in venation (usually given generic importance) the long winged condition apparently associated with a migrant habit.

The grasses which have been more particularly under observation during the season and which seem to have each its particular jassid fauna, are: Blue grass (*Poa pratensis*), *Andropogon scoparius* and *provincialis*, *Elymus canadensis* and *virginicus*, *Bouteloa hirsuta* and *cutipendula*, *Stipa spartea*, *Spartina cynosuroides*, *Sporobolus hookeri*, *heterolepis*, *asper* and *cryptandrus*. *Chrysopogon nutans*, *Muhlenbergia racemosa*, *diffusa* and *sylvatica*, *Bromus ciliatus* and *purgans*; also a number of annuals, especially the *Panicums* and *Setarias*.

A statement of the known host plants accompanies the discussion of each species.

TETTIGONIA BIFIDA SAY.

Journal Acad. Nat. Sci., Phila., IV, p. 313, 1831; Comp. Writings II, p. 387, 1869.

This is a rather handsome little species, and its range of food habit seems to be more restricted than many of the others, it being found only on blue grass in shady places. The latter restriction confines it to wooded pastures, where it is perhaps almost as common though less universal than *inimicus* in open pastures.

The adult is about six millimeters long, of greenish color, with circular alternate bands of black and white on the head and pronotum parallel to the border. The wings have seven black stripes, the outer one forking near the middle.

Adults are first recorded for July 11th, and were most abundant July 14th, becoming gradually less numerous till the first of September, when they disappeared. While egg deposition must occur during July or August it has not been observed.

The larvæ observed July 2nd to 20th were about half the length of the adults, fully as broad, with the surface of the body

of a powdery white appearance. The head is large, broad and deep, much inflated, almost round in front; eyes dark; wing pads broad and short; the abdomen inclined to be carinate dorsally.

They are decidedly different from the larvæ of any other species of *Tettigonia* studied in the much shorter body, a fact which would seem to indicate separation from the normal *Tettigonia* forms, and which allies them to *Euacanthus.*

While ordinarily considered a rather rare species this certainly occurs during a part of the year in its particular haunts in great numbers—that is in the rather rank blue grass of timber areas. In such locations it has been estimated to occur at the rate of 50,000 per acre.

DIEDROCEPHALA MOLLIPES SAY.

Tettigonia mollipes Say. Jour Acad. Nat. Sci., Phila., IV, p. 312, 1831. Comp. writings II, p. 386. *Aulacizes mollipes* Fitch. Homop N. Y. State Cab., p. 56, 1851. *Diedrocephala mollipes* Walker. Homop. Suppl., p. 233, 1858.

This species has been observed heretofore, and a record of two broods a year indicated. Observations this year show a somewhat later appearance of the spring brood, larvæ occurring through June and first week in July, adults appearing the last week in June, continuing through July, and to about the 20th of August. The second brood of larvæ appeared about the second week in August, running through September and maturing in October and November. First adults of second brood appeared about September 15th and continued through the season. Hibernation seems to occur in all stages, considerable irregularity being shown, but the main body being adapted to the hibernation of eggs.

The range of food plants is large, there seeming to be little choice between annual or perennial grasses. It has been recorded from *Adropogon scoparius* and *provincialis*, *Panicum crus-galli, scoparium; Setaria viridis* and *glauca.* Wheat, oats, barley (especially volunteer growth), slough grass (*Spartina cynosuroides*), wild rye, (*Elymus canadensis*). It cccurs less commonly on blue grass, probably in most cases only when other grasses are present.

As egg deposition in autumn is almost entirely confined to large-stemmed grasses, the destruction of these in pastures is advisable.

DIEDROCEPHALA NOVÆBORACENSIS FITCH.

Aulacizes novœboracensis Fitch. Homop. N. Y. State Cab., p. 56, 1851.

This is a larger and lighter colored species than *mollipes*, and may be further distinguished by the blunter head and the two black spots at the tip. It has been found to occur only in sloughs or in heavy grass adjacent to them, especially slough grass (*Spartina cynosuroides*).

The adults were taken through the last of June and through July, and again from the middle of August through September. It seems to be decidedly limited in its range of food plant, and would be of little economic importance except where slough grass is used for hay.

DIEDROCEPHALA COCCINEA FORST.

Cicada coccinea Forst. Nov. Species Ins., p. 96, 1781.

This is the brightest colored species of the genus occurring at Ames, and is intermediate in size between *mollipes* and *novœboracensis*.

The vertex and scutellum are bright yellow. The pronotum is variously marked with green, red and yellow. The elytra are bluish-green, with two broad purple stripes, and a narrow yellow margin. Below, all yellow, except a narrow black line just under the vertex. Length, nine to ten mm. Readily separated from *versuta* by the absence of dark markings on the vertex, and the larger size.

The larvæ are of a pale yellow color throughout. Head much inflated, convexly pointed, resembling that of adult but larger; thorax broad, abdomen long and slender. The pupæ are still lighter colored, and have a scarlet mark on each wing pad.

This species is two-brooded. The larvæ were taken nearly full grown about the 1st of June. Adults were taken from about the middle of June through July, and again through September and October.

They were taken from woody regions, but usually swept from the undergrowth of grass and weeds. Adults of the second brood were taken from coarse grasses long after the trees had shed their leaves.

XEROPHLOEA VIRIDIS, FABR.

(Pl. xix, Fig. 1.)

This grotesque species occurs throughout the entire United States at least. Van Duzee reports it from New York to Florida,

Texas, Colorado, and California. In addition to this, specimens are at hand from Oregon, Utah, Arizona and Nebraska, and it has been collected at Ames rather commonly.

The adults are six or seven millimeters long by two millimeters wide across the pronotum; the head is slightly narrower than the pronotum; eyes small; vertex flat, produced and roundingly angled in front, anterior margin very thin. The elytra are long and angularly pointed behind, the claval area is nearly flat while the corium is strongly deflected, becoming perpendicular at the tip, giving the insect a wedge-shaped appearance. The entire dorsal surface is coarsely pitted. The females are bright green with the tips of elytra lighter, sometimes clouded or minutely dotted with darker along the margins; the males have in addition a broad median smoky line on the vertex and an irregular transverse dark band on the pronotum more or less strongly margined with lighter before.

Genitalia: The last ventral segment of the female is divided medially to its base and consists of two long, roundingly pointed lobes; male valve broadly, obtusely rounding, length and breadth about equal; plates narrow, spatulate, two and one-half times the length of the valve.

Larvæ: Similar in form to the adult but with a broader body and longer head; vertex one-half longer than wide, acutely angled before, margin very thin, whole depth of head less than one-fourth the length of the vertex; abdomen short, dorsally carinate; color green, the entire surface covered with short white hairs arising from minute black spots; a pair of larger black spots near the base of the wing pads and another pair on the posterior margin near the inner angle.

Larvæ were found nearly full grown in August; the adults were taken from the second week in August until October. They were swept from a native grass pasture where they were fairly abundant. Specimens from Nebraska and Utah bear dates from May to July, indicating that the species is two-brooded. Observations were not made upon the field where it occurred during the first half of the season, which would account for its not being found sooner.

This species agrees in every particular with Burmeister's description and figure of *grisea* Germar, from Brazil, and undoubtedly it should be placed as a synonym of that species. But Fabricius' description of *viridis* from "Americæ insulis" precedes both, and though brief, agrees well with them and

probably characterizes the same species, at least so far as we know no other species which could answer their description occurs.* If this is correct the synonym will stand.

Xerophloea viridis Fab.

Cercopis viridis, Fab. Ent. Syst. IV 50, 13, 1794.
Xerophloea grisea, Germar Zeits. F. G. Entom. I, 190, 1, 1839.
Xerophloea virescens, Stal. Ofv. Vet. Ak. Forh., 1854, p. 94, 30.
Xerophloea viridis, Fabr., Stal. Hemiptera Fabriciana, II, p. 59.
Parapholis peltata, Uhler Bull. U. S. Geol. and Geog. Surv., III, p. 461, 1877.
Xerophloea peltata, Uhler Stand. Nat. Hist., II, p. 248. 1884.

Professor Uhler, in the Standard Natural History (vol. II, p. 248) gives the range of the species as from Massachusetts to Rio Janeiro in Brazil, thus covering the territory indicated by the three descriptions.

GYPONA GERMAR.

Although the *Gyponas* have never been recorded as grass-feeding species the observations this season show that for one of them at least this is an exclusive habit, and for others apparently a normal one.

The species are widely variable in color and size, and the genus needs a thorough revision in order to reduce to consistent species the long list of so-called species which has arisen from the characterization of these numerous varieties.

Structurally the species are very constant and present definite characters in the shape of the head, the venation and the genitalia.

GYPONA OCTO-LINEATA SAY.

Tettigonia octo-lineata Say Comp. Writ, II, 257.
Gypona striata Burmeister, Gen. Ins. Gen. 16, No. 9.
Gypona flavilineata Fitch, Homop N. Y., State Cab., p. 57.
Gypona quebecensis Provancher, Nat. Canad. IV, 352.
Gypona cana Burm, Gen. Ins, Pl. 16, No. 10.
Gypona flavilineata, Spangberg, Spec. Gyponæ, p. 8.

This is the longest and one of the narrowest species in the genus, on account of its long, narrow elytra, much exceeding the abdomen. It varies in size from large females eleven or twelve mm. long by three mm. wide down to the smallest males only seven or eight mm. long by two mm. wide. The vertex is two-thirds as long on the middle as the width between the eyes, front margin very thin, roundingly produced. Ocelli small, slightly behind the middle of the vertex; elytra long and narrowed to a blunt point behind. The venation is indefinite, consisting of fine reticulations on the apical half, and sometimes including the whole surface except the base of the costa.

* A series of thirteen specimens of this insect from Cuba, kindly sent by Mr. Robert Combs, shows most perfect agreement with Iowa specimens, and no other species of the genus is represented in his collecting.

Genitalia: Ultimate ventral segment of the female moderately long, nearly truncate behind, curved downward in the middle, giving it an emarginate appearance, the edge often thin and membranous. The last ventral segment of the male longer than the pronotum, truncate, concealing the valve. Plates narrow, ligulate, nearly four times longer than wide, longer than the last ventral segment, nearly equaling the pygofers, separated at the base by one-half their width, obliquely overlapping at tip. Pygofers broad at base, obliquely truncate from below, tips produced incurved and touching each other.

Color very variable, early specimens of both broods, especially of the first, light green, the yellow lines indistinct; elytra nearly hyaline, nervures weak. This form is the *flavilineata* Fitch, and *striata* Burmeister. Late specimens of the first brood and nearly all of the second are dark green with the elytra strongly reticulate. The yellow lines may be strongly marked or almost wanting; these include the forms described as *quebecensis* Prov., *cana*, Burmeister and *flavilineata* Spangberg. Specimens collected during the latter part of September and throughout October were more or less tinged with red, especially in the females. Specimens being taken which varied from the lines red, through forms that had the lines and the elytral reticulations red, to females that were almost entirely scarlet dorsally, these last being the typical *octolineata* form.

Throughout the whole series the structural characters, with the exception of the strength and number of the reticulations, scarcely varied.

These conclusions are based on the examination of hundreds of specimens showing the most complete intergradations in all these variations. In accord with the general rule for jassids, the first brood, mostly *flavilineata* form, are weakly veined, and those of the second brood, mostly *octolineata* form, are strongly veined and more highly colored.

Larvæ are very broad and depressed, more so than the adult, which it much resembles. The vertex is abruptly narrowed in front of the eyes, then strongly projecting with parallel margins and a broadly rounding apex, the whole projection extremely thin, antennæ nearly as long as body, basal joint as long as vertex, abdomen long and compressed; general color green.

The pupæ are broader, shorter, darker green than the larvæ, and have two fuscous spots on the inner angle of the wing pads.

Larvæ were found June 16th, small to half grown, continuing abundant until the middle of July. Adults appeared about the first of July, continuing till the middle of August. Second brood larvæ occurred into the latter part of August, and on through September. Adults appeared in September and October.

This is by far the most abundant species of the genus, and occurs throughout the entire region east of the Rocky mountains from Canada to Texas, at least, and is closely related to the South American *lineata* of Burmeister, if not identical with it.

In common with other jassids which have a wide distribution, it does not seem to be confined to any particular food plant, but may be found almost everywhere, preferring rank growths in shaded situations. It is the only representative of the reticulated elytral group occurring at Ames, and is unique in that it is two-brooded, while the other species are all apparently only single-brooded.

GYPONA BIPUNCTULATA WOOD.

Gypona bipunctulata, Woodworth, Bull. Ill. State Lab. Nat. Hist., III, p. 30, 1887. (♀)
Gypona nigra, Woodworth, Bull. Ill. State Lab. Nat. Hist., III, p. 31, 1887. (♂)

This is the largest jassid known to occur on grasses in Iowa, and presents a very marked difference between the males and females. The females described as bipunctulata by Woodworth are bright green, stout, deep-bodied. The vertex is short, ocelli small, and there are distinct black dots on the pronotum, one each side about half way from the middle to the margin; also a distinct dot on the base of each elytron just under the outer angle of the pronotum.

The male, which was described as *Gypona nigra* by Woodworth, has the head and pronotum black, margined with light green. The black color nearly conceals the dots of female pronotum. The elytra are hyaline and allow the black tergum to show through, so in most specimens there is usually a quite uniform dark color to the whole upper surface except the margin. The genital plates are broad, shorter than sixth segment, truncate at apex.

Woodworth described this species from Illinois, and we have specimens from Kansas aside from numerous examples taken in Iowa.

The adults appear the middle of July, the males about a week before the females, and continue to the latter part of September. They have been taken only from grasses.

Full-grown larvæ were swept from prairie grass July 6th. They are shorter, stouter, with shorter vertex, covered all over with stiff white hairs.

In addition to these a small larva was taken from the base of an *Elymus* stock, September 5th, and another larger one May 22d. This pupated in cage May 29th and died June 16th. These two larvæ are doubtfully referred to this species which, if correct, would indicate *Elymus* as the larval food plant.

EUACANTHUS ACUMINATUS FAB.

(Pl. xix, Fig. 3.)

Cicada acuminata, Fab. Syst. Ent. IV, 36, 40, 1794.
Euacanthus orbitalis, Fitch. Homop. N. Y. State Cab., p. 57.

Fitch's description of *orbitalis* and the specimens at hand agree in every respect with the description of *acuminatus* and with European examples of the species, so that there seems to be no question as to their specific identity.

This species occurs throughout the whole of central Europe, and probably has an equally general distribution in this country. It has already been reported from Canada, New York and Michigan, and specimens are at hand from Washington, D C., and Vancouver's Island, besides adults and larvæ taken at Ames this season.

The adult is very stout-bodied with a broad vertex and small round eyes. Length, 6 mm., width on center of costa, 2mm.

Vertex about equaling pronotum in length; nearly twice broader than long, obtusely angled anteriorly, medially and laterally carinate; ocelli on the vertex near the carinate anterior margin, about equally distant from eye and tip; front broad above, rounding to the small clypeus; base of the antennæ overhung; pronotum short; elytral venation simple, first sector only once forked; color, shining black with margin of eyes, tip of vertex, elytral nervures and a large spot near the base of the costa, white.

Genitalia: Ultimate ventral segment of the female long, rounding, posterior margin arcuated and slightly notched. Male valve obtuse, short; plate long and very narrow, exceeding the pygofers.

Larvæ white: Head similar in form to the adult, much more inflated and produced, one-third the length and nearly half the size of the whole insect, four times the length of the bead-like eyes, evenly and finely covered with short white hairs; antennæ extending beyond the middle of the abdomen; thorax narrower

than the prominent eyes; abdomen slender, dorsally carinate, tipped with coarse white spines; entire body covered with fine white pubescence; thorax and abdomen sparsely set with curved black hairs pointing backward. Length of full-grown larvæ 5.50 mm.

Larvæ and adults were taken the first week in July; adults continuing to be found throughout the month. Swept from a woody pasture in which numerous *compositæ* abounded. Larvæ in cages fed indiscriminately on a variety of plants taken from similar situations.

Although not hitherto recorded specimens of the other European species, *Euacanthus interruptus* L., have been represented in American collections but have been placed with Fitch's *orbitalis*. Those at hand are from South Carolina, but it doubtless has much the same distribution as *acuminatus* here, as it does in Europe.

The position of the ocelli in this genus is strongly suggestive of the *Acocephalinæ*, while in some other respects it appears to be more closely related to the *Tettigoninæ*. This and the following genus, which seem very closely allied, may very probably represent generalized or intermediate forms connecting the two sub-families.

NEOCOELIDIA TUMIDIFRONS G. & B.

Hemiptera of Colorado, p. 104.

The male of this species was described in "Hemiptera of Colorado," page 104. The female taken at Ames this season differs considerably from the male description, and may be characterized as follows:

FEMALE.—General aspect of *Euacanthus;* light yellowish-green above, no dark markings visible on the scutellum. Below, yellowish-green with rostrum, oviduct and spines on legs orange. Vertex furrowed and nearly parallel margined next the eye as in *Euacanthus*, but lacking the carinæ, then convexly conically rounding to the front; length on middle twice that next the eyes, width between eyes equaling length. Ocelli small, on the rounding margin of vertex as in *Xestocephalus*, about one-third the distance from the eye to tip. Front at ocelli one-half wider than at loræ. Antennæ inserted beneath a ledge, nearly as long as body; first and second joints large; pronotum very short on the middle, continuing broadly behind the eye and around back of the genæ as in *Euacanthus*. Elytra about equaling the abdomen; spines on the hind tibiæ very strong,

a crown of short spines on the tip of the tibia, and the first two tarsal segments.

Genitalia.—Ultimate ventral segment of female nearly as long as width at base, elevated in the middle; posterior margin truncate, with a broad median notch; pygofers narrow, moderately exceeded by the oviduct; the margins and tip studded with short, stout, orange spines; length, 4.50 mm.; width on center of costa, nearly 2 mm.

Larvæ.—Half-grown specimens taken the middle of September already possessed the characteristic head and pronotum of the adult. The antennæ were longer than the body, basal joints very large, and arising from under a well marked ledge; color, bright green, with six black spots, as follows: A pair of round ones occupying the anterior half of the eyes, a pair on base, and another on posterior margin of the wing pads, directly behind and in line with the eyes, anterior pair partly concealed by the pronotum. Spines on the genitalia, and legs stronger than in the adult.

This species was taken in upland pastures in which *Andropogon scoparias*, *Bouteloa hirsuta* and *curtipendula* predominated. Adults were taken the latter half of August; half-grown larvæ were found September 13th and 17th.

This is a very peculiar species, and suggests a relationship between *Euacanthus* and *Xestocephalus*, two of the lower genera, placed respectively in the sub-families *Jassinæ* and *Tettigoninæ*.

XESTOCEPHALUS PULICARIUS VAN D.

Bull. Buffalo Soc. Nat., Sci. vol. IV, 1894.

This is a narrow, convexly conical headed little species with broad maculate elytra and a brown vertex marked much as in *Tettigonia hieroglyphica*. Length about 3 mm.

This species might easily be mistaken for a *Deltocephalus* but for the ocelli which are situated nearly half way from the eyes to tip of vertex. It was found rather commonly on blue grass in shaded locations through July and August.

Very generally distributed north, and specimens have been received from Mississippi (Weed).

XESTOCEPHALUS CORONATUS N. SP.

(Pl. xix, Fig. 2.)

Form and size of *pulicarius* nearly, but with head and pronotum shining black, with white markings; length, female, 3 mm.; male, hardly 2.50 mm.

FEMALE. Head nearly equaling pronotum in width; vertex two-thirds the length of the pronotum, one-half longer on middle than next eye; width at base nearly twice the length, convexly rounding to the front; lateral and posterior margins, a median stripe extending forward across the disk, and ocelli white; tip white, broadly margined with orange. A broad lateral margin approaching so near the ocelli as almost to complete the white margin and reduce the black to a large spot on either side of the median line of the disk. Front narrow at ocelli, widening to antennal pits, then rapidly narrowing to the clypeus; light orange above, shading to black below; clypeus and loræ black; genæ broad, white; antennæ long, arising from under a distinct ledge; pronotum short, margins nearly parallel, black, with a transverse white band just before the posterior margin; scutellum, basal half black, with a narrow median stripe, apical half orange. Elytra maculate with black as follows: The middle and tip of clavus, apex of elytra, a small spot on the costa before the apex, a broad, slightly oblique band arising beyond the middle of the costa and extending to the clavus, branching before the middle and running narrowly to the anal cell and a smaller curved band near the base of the costa, sometimes uniting with a median one near the claval suture.

MALE. Vertex without the median stripe or orange marking; upper part of front and all the vertex within the white margin, shining black, except ocelli and a point on the tip equaling them in size, white; lower part of front and clypeus orange.

GENITALIA. Ultimate ventral segment of female very broad, posterior margin straight, roundingly notched in the center, slightly deeper than in *pulicarius*. Male valve short, obtusely concavely pointed; plates inflated, broad at base, concave, narrowing to an acute apex; apex curved upwards around the pygofers which, together with the plates, are margined with plumose white hairs.

Two males and one female of this very distinct little species were taken from a deeply shaded patch of bluegrass in August. Ames, Iowa.

THE SHOVEL-NOSED LEAF-HOPPER.

DORYCEPHALUS PLATYRHYNCHUS, OSB.

(Pl. xx, Fig. 1.)

Canadian Entomologist, XXVI, p. 216, 1894.

This very peculiar insect has hitherto been recorded only from Ames, Iowa, and West Point, Neb., and has been considered very rare, only three or four specimens in all having been seen prior to the present season. Nothing was known as to its life-history or food habit. During the present season, however, it has been found in large numbers, and since it has bred freely in the breeding cage, it has been possible to determine its full life-history.

At first sight one would infer that it would be a very conspicuous object, an easy victim for natural enemies or the

obtrusive collector. As a matter of fact this proves to be only a remarkable adaptation to its food plant (*Elymus*) in color, form and life-history.

The linear aspect and dark dorsal stripe, more or less broken or obscured, harmonize so well with the ordinary rusty *Elymus* stem to which it closely adheres and from which it can scarcely be driven, either in larval or adult stage, that it is detected with great difficulty. They rely on this mimicry for protection rather than upon flight or leaping. So perfect is this protection that one may look for some time at a few stems of grass where dozens of the insects are known to occur and fail to locate them.

The figure shows the distinctive features sufficiently and a full description is unnecessary here, but it may be proper to call attention to the fact that there are two forms of females, one having the elytra very short (wings proper rudimentary), as figured, the other with much longer wings and smaller body and more pointed rostrum, more closely resembling male. This flies readily while the other is entirely incapable of flight and never leaves the plant on which it is hatched. The males are all long-winged.

It is single brooded, the adults appearing about the middle of May and continuing in decreasing numbers until the end of July. During the last week in May and the first week in June the eggs are deposited; the female selects a spot about two inches above the base of the first or second leaf from the bottom; having selected the spot apparently with much care, she takes her position head upwards, legs placed close together and tarsi clasping the stem; then, raising the body the length of her legs and curving the abdomen upward, she unsheathes the ovipositor from the pygofers and brings its tip down against the grass stalk, pointing backward slightly from the perpendicular; she then moves slowly around the stem keeping the body parallel with it and the guides pressed firmly against it until they catch under the edge of the encircling leaf sheath; having done this they are gradually forced under the sheath, usually extending almost half way round the stem. As they are gradually forced in the abdomen straightens and then hollows until, when the ovipositor is fully inserted, the abdomen is curved down and the pygofers are pointed upward and backward at more than a right angle with the guides. Having reached this position she works slowly backwards, opening the

sheath downward with a peculiar sawing motion alternating with a slight pause for the deposition of an egg.

The eggs are one and one-half millimeters by one-third millimeter, cylindrical, gradually tapering from a point near the head back to an obtusely rounded tip; the anterior end is cut off obliquely from one side and rounded from the other, coming to an obtuse point. They are deposited in a continuous row, from thirty to fifty, side by side, curving slightly around the stem with their heads toward the edge of the sheath, from which they are distant about one-third the circumference. The time occupied in actual deposition is from twenty to forty minutes, but the selection of a location and the catching of the sheath edge often occupies several hours.

Although the eggs were deposited through a period of two weeks or more they apparently all hatched at about the same time; the time evidently depending considerably upon favorable conditions of temperature and moisture, for, up to July 2d, no larvæ had been observed either in the cages or in the field. On this afternoon the air was very oppressive, and remained so until cleared by a heavy thunder storm during the following night. On the morning of the 3rd they were observed just emerging from the eggs in the cage, and examinations showed that they had hatched in the field also. The earliest deposition from which they were observed to issue on this date was made May 28th, and the latest on June 9th, while the majority were deposited June 4th and 5th. This gives from twenty-six to thirty-eight days, with an average of about one month, as the period of incubation.

The freshly hatched larvæ have shorter and blunter heads than the adults, and are much more active, but within a week or two the head has elongated, and it has adopted the sluggish habit of the adult.

Upon hatching, the larvæ immediately arrange themselves along the base and margins of the broad leaves parallel to the veins, where they remain stationary for weeks at a time, so closely resembling the rust spots and discolorations occasioned by their punctures that the chance of their detection is slight, or, they ascend to the head, where they conceal themselves so effectually among the glumes and sheaths upon which they feed, that one might carefully examine a head and pronounce it free from them, only to find, on shaking it violently, that it contained a whole colony. Here they stay until the head ripens

in September, when they descend to feed on the second growth and the surrounding grasses until winter, when they crawl into the thick clump of the *Elymus* and hibernate, appearing again in early May and changing to pupæ. From then on until the middle of the month they feed on any green plant, near enough to be reached, crawling at last to the top of some blade of grass and issuing as adults over ten months from the time of hatching from eggs.

This species in common with the others which occur in long and short-winged forms, are usually very thick, where they occur at all; but, the eggs being deposited only upon the *Elymus*, they are limited in their range to a radius of a few feet at most from their host.

They have been observed to feed upon the heads of *E. virginicus* indiscriminately with those of *canadensis* where the two grasses are near together, or near enough for migration, and in the spring, when the larvæ were large and abundant and the grasses small and inconspicuous, they were found upon everything occurring within a reasonable distance of the host.

In view of the fact that wild rye is one of the most deleterious of our grasses, and has been the cause of considerable loss to our stockmen in the past through its propensity to ergotism its eradication from pastures and meadows would of itself be beneficial, and at the same time avoid any possibility of further injury from this species of jassid. Another method which would accomplish both ends sought and still enable us to make use of its valuable food properties would be to closely mow the *Elymus* clumps the latter part of each June. This would cut off the head-forming stems before they had developed ergot, and would destroy the eggs of the shovel-nose, and at the same time leave the grass in good condition for immediate pasture, or, if not pastured, produce a better crop of hay than without the mowing.

THE SPOON-BILL LEAF-HOPPER.

HECALUS LINEATUS UHL.

(Pl. xx, Fig. 2.)

Glassocratus lineatus Uhler. Bull. U. S. Geol. and Geog. Surv. III, p. 464, 1877 (♀)
Glassocratus fenestratus Uhler. Bull. U. S. Geol. and Geog. Surv. III, p. 464, 1877. (♂)

This rare species is intermediate in form between the *Dorycephalus* and *Parabolocratus*. The female measures 12 mm. to the tip of the exserted, attenuate ovipositor. The head is 2.50 mm.

long by 2 mm. broad, slightly narrowed in front of the eyes, widening immediately to a spoon-shaped tip, which is thin and slightly reflexed. The body color is bright green with four equidistant parallel lines extending over head, thorax and scutellum; the nerves of the elytra and the ovipositor orange red.

The males are quite different from the females in appearance, and were described by Professor Uhler as *Glossocratus fenestratus*, and have hitherto been regarded as a distinct species. They are much smaller, measuring scarcely 8 mm. to the tip of the style-like pygofers.

The head, thorax and basal part of the elytra are marked like the female, but the ground color approaches orange. The apical half of the elytra and the abdomen are quite different. There is a narrow black band just back of the middle of the elytra and a broader terminal one, between these is a hyaline area with a small curved dark spur extending in on the center of the outer margin. The abdomen is annulated with black, and the terminal segment, valve and attenuate plates black.

The larvæ are narrow, elongate, closely resembling the female in color and in the stripes which extend along the abdomen also.

The species has been reported from Kansas and New Jersey, including only a few specimens in all. There was a specimen in the VanDuzee collection from New York, and one specimen had been taken at Ames and another at Batavia, Iowa.

The larvæ were found on an isolated patch of slough grass (*Spartina cynosuroides*) early in August. They were then nearly full grown.

The adults were taken *in coitu* in the middle of August, and from then on through September were found in some numbers on the limited patch where their food plant occurred.

It is highly probable that the eggs were deposited in the stems of the slough grass before the middle of September, in which case the ordinary time of mowing would be an effectual remedy, and would account for the rarity of the species in cultivated areas, or in sections annually overrun by prairie fires.

PARABOLOCRATUS VIRIDIS UHL.

(Pl. xxi, Fig. 1.)

Glossocratus viridis, Uhler, Bull. U. S. Geol. and Geog. Surv., III, p. 462, 1877.
Parabolocratus viridis, Uhler, Stand. Nat. Hist. II, p. 247, 1884.

Occuring only on the wild oat (*Stipa spartea*) this species furnishes another example of a jassid confined strictly to one species of grass as a host and one to which it is remarkably adapted in coloration and life-history.

The adult female is about 7.50 mm. long by 2 mm. broad, with a parabolically curved, thin edged vertex and a stout abdomen, attenuating posteriorly and extending beyond the rounding elytra. The males are smaller and have the vertex shorter and more obtusely pointed. The abdomen is smaller and does not extend beyond the narrow and nearly parallel margined elytra.

They are both of a uniformly deep green color above, somewhat lighter below, with a narrow band under the sharp vertex, and the eyes dark; the exserted tip of the ovipositor, orange red.

The first brood of the adults appeared the first week in May and remained until the middle of June, disappearing gradually. They feed principally upon the leaves usually about the middle, feeding on either side and either end up, with equal ease.

The eggs are deposited during the last of May and the first week in June. The females usually selecting a position just above the first leaf base and invariably placing themselves head downward, exsert the ovipositor and insert it under the flap of the sheath, gradually working backwards up the stalk for a distance of two inches or more and depositing from seventy to one hundred and twenty eggs within an hour.

The eggs are 1.25 mm. long by .25 mm. broad, cylindrical, of nearly uniform size and obtusely pointed at both ends, arranged in a single series, side by side, curving considerably around the small stem.

The larvæ appeared the last week in June, giving an incubation period of fifteen to twenty days. Upon bursting the egg case the larvæ crawl part way out from under the sheath and remain quiescent in this position for an hour or two when, becoming suddenly active, a flock of very small larvæ may be seen ascending the stalk and distributing themselves upon the leaves, while a row of freshly shed skins with the abdomens still remaining under the sheath, their tips scarcely free from the egg shells, explains the cause of the delay.

When first hatched the larvæ have a characteristic head, depressed, light colored, soon deepening, however, and in some assumes more or less definite stripes of darker which; in the most extreme forms coalesce, and a black specimen is the result. In normally colored specimens there is on either side of a median light line a narrow black stripe originating in a spot on the anterior margin of the vertex, obscured across the disk and

becoming marked again upon the posterior margin, enlarged and lobate on the thorax, then narrow with definite parallel margins to the last segment of the abdomen, where they expand and meet at the tip. Besides these there is a broad stripe extending from the inner angle of the eye back across the thorax, where it is margined internally with light to the abdomen, where it margins all but the last segment.

They require about a month to develop, maturing during the latter part of July and the first of August, the adults remaining until the middle of September.

The eggs for the second brood are deposited from the middle to the last of August and the larvæ appear in September, becoming full-grown before winter, when they hibernate, appearing to pupate about the first of May and becoming adults before the middle of this month.

Stipa is another troublesome grass, but too widely and evenly distributed over the prairies to eradicate easily. It may, however, be mowed closely between the 10th and 16th of June to destroy the first brood of eggs and the troublesome barbs of the grass at the same time, leaving an undergrowth of nutritious grass free from jassids. Then, should the adults appear in considerable numbers in August, a second mowing during the latter part would effectually dispose of the second brood of eggs.

Stipa is a very valuable grass to the stockmen of the prairie regions, where blue grass has not been introduced, as it appears two or three weeks earlier than the other wild upland grasses, thus furnishing much earlier grazing than could otherwise be obtained.

PLATYMETOPIUS, BURM.

The American representatives of this genus agree with the European *P. vittatus*, Fab., in form and the generic characters may be stated for our species as follows:

Head distinctly narrower than the pronotum; vertex narrow, produced and very acutely angled, making an acute angle with the face. Face long, narrow, front long, broadest at the ocelli, narrowing above to the tip of the vertex, below to the antennal pit, from them to near its apex nearly parallel margined, narrowing slightly to the clypeus; clypeus strongly constricted before the middle, widening to the broad apex; loræ subovate; pronotum short, strongly produced beneath the eyes, lateral margin long. Elytra with more or less of fine irrorations in the areoles and small hyaline white points near the ends of the

cells; two cross nervures and a series of cross veinlets along the hyaline costa always present.

The genitalia seem to be very constant and very similar in the different species and are consequently of little value as specific characters. The last ventral segment in the female is long, obtusely angled or rounding posteriorly. The last segment in the male is angularly excavated; valve large, roundingly pointed. The plates are broad and also convexly pointed, similar in shape to the valve and about twice its length.

The three species occurring at Ames agree in being two-brooded, the broods occurring at about the same time, the adults appearing in June and again in August, remaining less than two months each time. The larvæ, of the three species at least, agree in being broadest at the middle, pointed at both ends, light, with dark margins extending in front of the eyes and meeting under the vertex.

PLATYMETOPIUS ACUTUS SAY.

Jassus acutus, Say, Jour. Acad. Nat. Sci. Phila., VI, p. 306, 1831; Compl. Writings, II, p. 382, 1869.

Platymetopius acutus, Uhler, Bull. U. S. Geol. and Geog. Surv., III, p. 473, 1877.

This widely distributed form may be recognized by its remarkably, acutely, pointed vertex and narrow elongate face, together with a row of black marked cross nervures along the costal border and the finely irrorate elytra. Length, 5 mm.

The larvæ resemble the adults in having the head elongate, narrower than the pronotum. When full-grown they are about four and one-half millimeters long by two millimeters broad in the middle where they are the widest, and from which they gradually and about equally, narrow to an acute point at either end.

Color: There is a broad dorsal light stripe including all the vertex, parallel margined across the thorax where it is slightly wider than between the eyes, constricted on the base of the abdomen and again before the tip expanding on the disk of the abdomen, and again on the extreme tip. This stripe is distinctly red on the center, shading out to creamy white on the margin. The constrictions on the abdomen sometimes completely dividing it into two spots, one on the disk and another on the tip. A marginal black stripe extending the entire length of the body on either side, meeting entirely below the edge of the vertex in front, including numerous fine white maculations. Below, inside the marginal stripe, creamy white.

The larvæ appear the latter part of May, maturing before the end of June, adults appearing before the middle of June and continuing till the middle of July, larvæ again appearing in July, maturing in August, adults from the middle of August on into October. The larvæ were taken in grass lands but were more abundant in shady situations.

PLATYMETOPIUS FRONTALIS VAN D.

Canadian Entomologist, XXII, p. 112, 1890.

This species may be readily recognized by its much darker appearance, being dark brown to black with a broad lemon-yellow face and the small round white spots in the ends of the elytral areoles distinct. It is slightly shorter and stouter than *acutus* and has a shorter vertex.

The larvæ bear a strong superficial resemblance to those of *Deltocephalus inimicus,* but may be readily separated by the presence of the marginal stripe in front of the eyes

Form and pattern of ornamentation similar to that of *P. acutus* but much shorter and stouter. Vertex very much shorter.

Color: A dorsal light yellow to cream-colored stripe narrowing to a point on the tip of the vertex, broadening with irregular margins on the disk of the abdomen, interrupted before the tip by a narrow black band on base of last segment. Marginal dark stripe extending equally above and below the border of the vertex meeting in a point at the apex, a small lobate expansion of the dorsal stripe midway between edge and tip of vertex just behind the white frontal suture. Below, white, tip of posterior femur and second tarsal joint annulated with black.

Life-history similar to that of *acutus;* larvæ from the last of May nearly through June; adults from the middle of June nearly through July; larvæ from the middle of July nearly through August; adults from the middle of August through September.

Found exclusively in shaded situations; larvæ were swept from undergrowths of grass and weeds.

This species has a quite extended distribution, being credited by VanDuzee to Canada, New York, Illinois, Iowa and Kansas, and as it does not occur in such abundance as some of the other species, and would, therefore, be less likely to appear in collections, it may be assumed to occur throughout the northern United States east of the plains at least.

PLATYMETOPIUS CINEREUS, N. SP.

(Pl. xxvi, Fig. 1.)

Form of *P. acutus* but smaller and lighter colored, equaling *fuscifrons* in size. Length, female nearly 4 mm., male, 3.50 mm.

Female: Vertex nearly twice as long as broad, slightly more than twice as long on the middle as next the eye; light yellowish with fine brownish irrorations; a median light line, broadest on tip fading out on the disk, on either side of this a curved line extending back from the edge on to the disk. Front with the usual dark V under the vertex, remainder of the vertex and the clypeus light lemon-yellow; loræ and genæ slightly, finely maculate with brown; pronotum short, fulvous brownish, lateral margins long, posterior angles obscure, emarginate; between them traces of longitudinal light lines; scutellum large, light yellow, tip darker. Elytra light with fulvous brown irrorations; apical and costal veinlets dark, terminal spots in cells and costal margin whitish-hyaline; tip slightly clouded with dark fuscous.

Male: Smaller and shorter, the vertex is only about one and one-half times as long as broad and the terminal cells are clouded with fuscous.

Genitalia: Ultimate segment of the female long, rounding behind narrowly notched in the middle, slightly lobately produced either side of the notch; pygofers light yellow, three times as long as width at base. Male valve large, roundingly pointed, dark at the base; plates roundingly pointed, twice the length of the valve, maculate.

Larvæ: Similar in form to those of *acutus* but smaller; they are about three and one-half millimeters long by one and one-half wide in the middle when full-grown. Widest just before the middle, gradually and regularly narrowing to an acute point at either end. There is a broad lemon-yellow dorsal stripe, narrow, wedge-shaped on the vertex with indefinite margin; broad, with definite parallel margins on the thorax, constricted slightly on the base and again before the extremity of the abdomen, bordered on either side by a dark fuscous marginal stripe, irregular in width, narrow before the eyes, meeting under the vertex. Numerous fine white maculations of various sizes dot this stripe.

The larvæ are readily distinguished from those of *acutus* by the absence of red in the dorsal stripe, and from those of *frontalis* by the much more elongate form.

The larvæ were first observed early in June, when they were nearly full grown, and by the third week had disappeared. The adults appeared very thickly by the middle of June and continued in decreasing numbers until after the middle of July. The second brood of larvæ appeared by the last of July and continued in large numbers up to the middle of August. The second brood of adults appeared the second week in August, continuing through September.

This is the smallest known species of the genus, and the most abundant at Ames, occurring everywhere that wild grasses are found. Specimens have also been received from Kansas, Nebraska and Arizona, showing it to have a wide distribution throughout the prairie and plain region at least.

By a process of elimination of grasses not occurring in places where the larvæ were found abundantly its list of host plants

may be reduced with a reasonable degree of certainty to three: *A. scoparius*, *B. hirsuta* and *curtipendula*, and from its scarcity in a field of nearly pure *scoparius* its probable host is a *Bouteloa.* This agrees well with its known habitat, which corresponds with that of these grasses.

REVIEW OF THE GENUS DELTOCEPHALUS.

This genus is distinctively a group of grass-feeding species, probably the most important in this relation on account of its wide distribution and large number of species occurring annually in immense numbers.

The genus was originally founded by Burmeister, who characterized it as follows: Vertex acutely triangular, distinctly margined; width between eyes scarcely equaling length; front broad, convex; vertex flat. Fieber in his synopsis of the *Deltocephali* adds the presence of two cross nervures between the forks of the first sector and the second, as a sub-family character. Later writers have omitted the head characters and depended upon the cross nervure alone for group separation. Mr. VanDuzee, to whose careful and accurate work we owe the greater part of our present knowledge of the American Jassidæ, seems to have accepted and used this character against his own better knowledge and judgment, for, in Entomologica Americana (vol. V., p. 93) he says: "This apparently trivial and not infrequently variable character seems almost inadequate for use in separating these two genera, but, correlated as it is with other structural peculiarities, of which it is the most pronounced, it appears to answer well the purpose of its employment, and is much used by Fieber and other European entomologists in synoptical arrangements of the genera." A few years later he described *Athysanus instabilis*, *extrusus* and *sexvittatus*, placing them correctly in that genus despite the fact that most of the types exhibited the two nervures, thus showing that he appreciated the true generic character. The next year, however, he again yielded to the demands of this variable character and redescribed *D. nigrifrons* as *Thamnotettix perpunctata*, although evidently appreciating their specific affinity, as seen by the following extract: "This insect, though quite distinct generically from *D. nigrifrons*, is difficult to distinguish in specific characters; the markings are almost identical, and the form of the facial and genital pieces differ but little." Dr. Melichar, in his recent work on The Homoptera of Middle

Europe, uses this single character in his synoptical arrangements as a primary basis of division for separating groups of genera, but evidently does not accept it in his distribution of species, as he places species that possess the two cross nervures in connection with a similar forking of the first sector to that laid down for the deltocephali in both *Thamnotettix* and *Athysanus;* while on the other hand he includes under *Deltocephalus* species in which the second cross nervure is wanting.

If the only result of these discrepancies was the misplacement of a few species with respect to their apparent natural affinities it would not be worth while, in consideration of the chaotic condition of other jassid genera, to attempt to restrict one genus at the expense of still more overburdening others. But upon an investigation of the actual conditions existing it has been found that species variable in this respect exist in large numbers, and that they have been and are being described over and over again under different appellations, according as their variable venation places them generically, now appearing as a *Thamnotettix*, now as an *Athysanus*, or even as *Eutettix*, and seldom failing to get at least one representative in *Deltocephalus.*

The variable species may be roughly divided into three classes: First, those species which vary between the opposite sides of the same individual, or between two individuals otherwise exactly alike. *Athysanus extrusus* and *sexvittatus* and *D. concentricus* are good representatives of this class. Second, species which have two distinct forms, both long winged, one form greenish in color and strongly resembling *Thamnotettix*, with only one cross nervure, the other form darker, with subhyaline elytra, possessing two cross nervures, and the other accompanying changes, notably the constriction of the central anteapical cell. *D. nigrifrons*, with its list of synonyms, well illustrates this group. Third, a group in which there are two forms with radically different elytra; one in which the wings are abortive and the elytra only cover the second segment of the abdomen; the venation simple, often rudimentary. In this form the female abdomen is usually very long, ending in an attenuate ovipositor; the male abdomen short, with much enlarged genitalia. The other form, with well developed wings and elytra; the venation variable, but usually strongly Delto cephaloid; both male and female abdomens normal. The forms described as *D. argenteolus* and *minutus*, and as *Athysanus gammaroides* all possess these two forms.

The examination of several hundred examples embracing some twenty species at present referred to five different genera and including all of the above mentioned variations compel the rejection of the cross nervure as an absolute character, or one capable of even specific recognition, except as correlated with other characters, and the re-establishment of the Burmeisteran genus based on head characters. It may be noted, however, that when thus restricted, it contains no species lacking the cross nervure nor any in which it is found to be variable.

The material upon which the revision has been based, and which has been accumulating during a number of years past, consists mainly of the following: Types of the ten VanDuzee species; types or typical specimens of all but two of the Gillette and Baker species, together with a series of several hundred Colorado specimens, received through the kindness of Professor Gillette. Twenty European species of the genus as defined by Melichar, more than half of them direct from him, which, in connection with his recent synopsis, furnish a good basis for comparison of the American and European faunæ. The Van Duzee material in the genus outside of the types, which, together with them, includes all but one of the eighteen described species which he listed in his catalogue. And, lastly, the college collections of thousands of specimens of adults and larvæ, together with a large series of balsam mounts of larvæ, elytra and wings, structural details and dissected genitalia for microscopic examination. These, embracing twenty-five species, among them the one lacking from the VanDuzee material, and thus complete the series of described American species.

After restricting the genus it was found that it could be separated into three well defined groups, each of which has its parallel in the European fauna. In fact, two out of the three groups possess species common to both continents. The first, or reflexed veined group includes species with short pronotum and sharp margined head; the elytra have little or no appendix and the costal veinlets are white-marked, strongly reflexed in one series and nearly right-angled in another. Of this group *bilineatus* represents one extreme and is closely related to the European *formosus*, while *ocellaris* common to both continents, and *sayi* closely related to the European *flori* and *socialis*, represents the other. They agree in being of a general light brown color with definite markings, and are two-brooded as far as known. The larvæ are light, with four brown stripes. The

species of the second group have longer pronotum, longer, narrower elytra, with an appendix, never possessing reflexed veins. Here is placed *debilis*, which is closely related to the European *abdominalis* and *melscheimeri*, which is intermediate between the European *notatus* and *striatus*. The group is nearly unicolorous, without distinct markings; the larvæ are unicolorous, usually yellowish in color. The third group, of which *inimicus* is the best known, have shorter, rounding, more centrally produced heads, with a row of points on the anterior margin of the vertex, extending down to the antennæ on either side. The central ante-apical cell is constricted in the middle and divided by a short nervure. They are closely related to the European *pulicarius*, and, like that species, not typical Deltocephalids. They are of a general dark color, more or less maculate. The known larvæ are dark margined or banded.

It has been thought best to place this group here for the present, though in a revision of the family it may prove necessary to establish another genus which shall include also such forms as *nigrifrons*.

SYNOPSIS OF AMERICAN SPECIES.

A. Vertex strong, disk flat or concave, margin in front of eyes straight. Ocelli on a level with the disk of vertex before the upper margin of eye.
- B. Pronotum short, more than twice broader than long, nearly truncate behind, posterior angles obtusely rounding, side margins long, elytra without a distinct appendix—light colored species with brown markings, larvæ light, with four brown stripes.
  - c. Elytra moderately long, with two outer apical veinlets strongly reflexed to the costa, the next one meeting the costa at nearly right angles, all three white, dark margined.
    - d. Pronotum four-lined, lines sometimes coalescing, black.
      - e. Vertex longitudinally lined or else spotted, ground color, yellow; front, narrow............... *bilineatus*.
      - ee. Vertex transversely lined before the eyes, general color white, front broad, inflated....... *albidus*.
    - dd. Pronotum cinereus, never distinctly dark-lined.
      - e. Third apical cell larger than anal one, face dark above, light below; species four mm or more long.
        - f. Face light or fuscous above, shading out below, no sharp line of demarkation, claval veins not uniting, vertex short, nearly right angled, male genitalia inflated, plates roundingly pointed; species nearly unicolorous above, except a broad spot in third apical cell.............................. *inflatus*.
        - ff. Face black above, white below, line of demarkation sharp, vertex, long, acutely pointed, dark markings above, sharp, veins on clavus coalescing through the middle third, male plates long, acutely, slightly concavely pointed ....*reflexus*.
      - ee. Third apical cell smaller, or only equaling anal one, face usually entirely dark; species less than four mm. long.

f. Length three and one-half mm. or over, ventral segment of female, with four black, comb-like teeth, male plates broad, almost truncate; species brownish fuscous above.. ... . *pectinatus*.

ff. Length, three mm. or less, ventral segment of female with a broad median projection slightly notched in the middle, arcuated either side, male plates roundingly pointed; species light cinereus above.... *abbreviatus*.

cc. Elytra shorter, broadly obtusely rounded, with the two outer apical veinlets short, at nearly right angles to the costa, third veinlet running distinctly to the posterior margin; species stout bodied, with chocolate brown markings.

d. Vertex slightly longer than broad; species not over three and one-half mm. in length, short and stout, with a distinct marking.

e. Dark chocolate brown above, nearly black below, a distinct inverted T on apex of front, claval sutures reticulate, central anteapical, cell divided; male valve large, inflated ....*ocellaris*.

ee. Light brown above and below, no reticulations on clavus, central anteapical cell entire, male valve normal, not larger than ultimate segment ....*sayi*.

dd. Vertex very broad, breadth and length about equal; species over four and one-half mm. long, markings brownish fuscous or wanting, male plates broad, short, obliquely truncate ....*configuratus*.

BB. Pronotum longer, hardly twice broader than long, posterior angles strong, sides short, postero-lateral margin nearly parallel with scutellar margin of elytra, elytra long with appendix, costal veinlets never reflexed, only the first one, ever even right angled; species unicolorous, yellows or fuscous, larvæ unicolorous.

c. Elytra only slightly overlapping at tip. Central ateapical cell neither markedly constricted nor extending posteriorly much beyond the adjacent cells, equaling or shorter than outer discoid cell.

d. Elytra distinctly green. Vertex lighter, not distinctly lined, tergum and venter and sometimes all of lower side of face varying to black.

e. Form stout; length four mm. or over........*debilis*.

ee. Form more slender; species three mm. or less in length.......................................*minimus*.

dd. Elytra not distinctly green, hyaline yellowish, or with the nervures fuscous margined; vertex unicolorous or lined, not spotted.

e. Male valve enlarged, inflated, rounding posteriorly concealing all but the tips of the small plates; female segment slightly angularly excavated...... ....*melscheimeri*.

ee. Male valve normal, less than half the length of the plates, last segment in female produced more or less notched.

f. Species distinctly yellow, male plates not longer than broad........ ....*oculatus*.

ff. Species fuscous or greenish, with fuscuous markings, male plates distinctly longer than broad.

g. Vertex acutely angled; species green, with slight fuscous markings; male valve pointed, female segment with truncate process............*sylvestris*.

gg. Vertex little more than right angled; species, brownish fuscous, with light nervures, male valve large, obtusely rounding, female segment deeply notched ....*cinereus*.

cc. Elytra broadly overlapping at the tip, central anteapical cell elongate, constricted, distinctly longer posteriorly than the cells on either side, longer than the other discoid cell.

d. Vertex orange yellow, general color yellowish, styles distinctly exceeding the long plates... ....*auratus*.

dd. Vertex light fuscous with brownish maculations general color fuscous, styles not visible beyond the short, broadly truncate plates ....*signatifrons*.

AA. Vertex short, disk convex, margin in front of the eyes arcuated, tip bluntly produced; ocelli below the disk of the vertex in front of the middle of the eye.

BBB. Pronotum long, distinctly angled behind, side margins long; species dark maculate or black; a series of small points on the anterior margin of the vertex, between the ocelli. Known larvæ margined or banded.

c. Clavus with a series of reticulations between the outer nerve and the suture; species fuscous, with black points on the vertex, elytral nervures light.

d. A pair of large, round, black points on anterior margin of each, vertex, pronotum and scutellum; length four mm..*inimicus*.

dd. Points small, usually confined to the vertex, species shorter, length three mm.

e. Elytra distinctly longer than abdomen, vertex acutely produced in the middle; male plates convexly pointed, width at middle two-thirds their length. ... .*weedi*.

ee. Elytra about equaling abdomen, vertex more obtusely rounding, male plates concavely attenuate, four times as long as width in the middle.. .... *compactus*.

cc. Clavus without reticulations along suture; species black, with white points on vertex, outer two apical veinlets white, costa yellow...*flavocostatus*

DELTOCEPHALUS BILINEATUS G. & B.

Hemiptera of Colorado, p. 85.

This species is very closely related to the *European D. formosus*, and like it, is very variable in color, ranging from almost black through distinctly black-striped forms to red-striped forms with black spots, and even on to those in which the black is almost wanting. It may be readily distinguished, whatever its color, by the reflexed white veinlets and its narrow elongate front. The dorsal stripes are always indicated, though variously colored and spotted. The general ground color beneath is some shade of yellow and the long plates of the male are broadly black tipped. This species was described from Colorado and has been collected at Ames, also in New Hampshire by Professor Weed. The Iowa specimens were taken in July from the undergrowth in a woody pasture where *Scaphoideus jucundus* occurred, which species it sometimes closely mimics.

DELTOCEPHALUS ALBIDUS N. SP.

(Pl. xxiii, Fig. 1.)

Clear milky white; a transverse line on the middle of the vertex, a circle around the tip and four stripes on the pronotum, black. Elytra flaring with reflex, dark margined costal veinlets. Length, 4.25 mm. Width of elytra on center of costa, 1.75 mm.

Vertex rather more than twice longer on middle than at eye, longer than width between the eyes, anterior angle slightly acute. Front broad, strong, twice wider on ocelli than at clypeus, sides straight, angle of the vertex less than forty-five degrees; genæ short, rounding, outer angle obscure; pronotum two and one-fourth times wider than long, feebly emarginate posteriorly; posterior angle indefinite. Elytra flaring, without an appendix, obtusely rounding posteriorly; venation distinct, the two outer apical veinlets strongly reflexed to the costa, the third one at nearly right angles to the costa and with the apices of the second and third anteapical cells forming nearly a straight line to the tip of the clavus, thus leaving two costal cells and three terminal cells, of which the outer one is the largest.

Color: Pearly white; above, tip of vertex triangularly margined with dark; a transverse slightly curved line on vertex, four longitudinal stripes on pronotum, the inner pair continuing across the scutellum and extending forward on to the base of the vertex, where they diverge, dark brown or blackish. Sutural and apical margins of elytra and anterior margin of the three outer veinlets lined with black. An oblique interrupted band from the tip of the scutellum to the center of the elytra, deep black. Tergum lined as in larvæ, the outer pair of stripes meeting above on the pygofers, forming a black V. Abdominal pleurites with a black margin and central dot.

Genitalia: Male valve large, acutely angled; plates twice the length of valve, narrowly, slightly concavely, pointed. Ultimate ventral segment of female twice the width of the penultimate; posterior margin divided into three broad lobes, central lobe notched one-half its depth. Described from numerous specimens.

Larvæ: Pearly white with four narrow brown stripes. Vertex acutely angled, three times as long on the middle as next the eye; body narrow; abdomen long, gradually tapering, acutely pointed. Color, pearly white above with two brown stripes arising just under the tip of the vertex passing up either side on to the disk, where they broaden, narrowing again toward the base, extending as narrow parallel lines ending abruptly on the posterior margin of the ultimate segment; a broad stripe on either side, arising behind the eye and extending back along the dorsum just inside of the white margin, meeting at the tip of the abdomen. A white spot on each abdominal segment within this stripe; a narrow white lined triangle on anterior third of vertex enclosing the point. Below, two stripes arising within the first pair just under the vertex, running broadly and obliquely across the face just under the eye, obscure or wanting on the thorax, margining the connexivum and meeting on the genitalia. Legs with small

round spots; posterior femora with a long dark line; middle femora with a transverse band below. These at rest complete the ventral stripe across the thorax.

This exceptionally well marked form may be easily recognized by its clear white ground color. It has been collected at Ames for several years but has not been received from any other locality.

The larvæ were first taken May 26th. They were then nearly full-grown and remained abundant for two weeks, disappearing by the middle of June. The adults were taken the 3d of June, and by the middle were exceedingly abundant, continuing in decreasing numbers up to the middle of July. The only appearance of a second brood was the capture of an adult male August 18th.

The field where this species occurred had been closely mowed June 25th, and the inference is that eggs had all been deposited in the grass stems above the point of cutting and must have been almost totally destroyed by the mowing. From these facts and through comparison with the life-history of other species their life-history may be, with reasonable certainty, completed as follows: Second brood of larvæ from the second week in July on to the middle of August; adults through August and September.

No definite food habit can be assigned, as there was a rich variety of native grasses where it occurred so abundantly. It was not, however, found on a field of *Andropogon scoparius* nor where the *Bouteloas* predominated. Insectary tests to ascertain its food plant failed because of its great susceptibility to *Sporotrichum* in confinement.

DELTOCEPHALUS INFLATUS N. SP.

(Pl. xxii, Fig. 2.)

Form intermediate between that of *albidus* and *configuratus*. Color very similar to *configuratus* usually a dark blotch in the third apical cell. Length, 4.25 to 4.75 mm. Width across center of costæ, 1.75 mm.

Vertex scarcely twice as long on middle as next the eyes, one and one-fourth times as long as broad. Front more than twice as wide at ocelli as at clypeus; facial angle acute, as in *albidus;* front less inflated. Pronotum short, weakly angled; elytra flaring, variable in length, usually exceeding the abdomen, venation similar to *albidus*, costal veinlets not as strongly reflexed, shorter.

Color, dirty yellowish-white to light fuscous with faint markings, tip of vertex ivory white, narrowly, interruptedly margined with dark, a line just

inside the margin before the ocelli, an obscure rectangular mark just on either side the center and an oblique spot near the base, brown. Pronotum and scutellum faintly lined. Elytra sub-hyaline, nervures light, sometimes faintly margined; oblique band reduced to two spots; usually a dark blotch in the third apical cell and reflexed nerves lightly margined. Below, dirty white; upper half of the face usually dark with white arcs. Tergum with four black stripes, outer pair widest at base.

Genitalia: Ultimate ventral segment of female very long, central fourth slightly produced, notched in the center, arcuated and dark colored each side of the notch. Male genitalia much enlarged; pygofers enlarged, inflated, spoon-shaped, their tips compressed; last tergite much enlarged, inflated, compressed laterally and terminally against the pygofers. Valve large, acutely angled, plates small, about twice the length of the valve, roundingly pointed, distended, and sometimes notched at tip by the sharp edge of the pygofers. Described from eighteen specimens.

The enlargement of the male genitalia, though not peculiar to this species alone, is rendered all the more striking from the fact that it is ordinarily met with only in the males of short-winged forms usually placed in the genus *Athysanus*, while long-winged forms of the same species in that genus have genitalia of normal size. The males of this species, however, are all long-winged and have constantly deltocephaloid venation and enlarged genitalia.

This species very much resembles *reflexus*, but has a broader head, stouter vertex and longer elytra, giving it a linear rather than a wedge shape. Specimens have been collected at Ames for a number of years and two examples were received from Colorado through Professor Gillette.

Adults have been taken rather sparingly through the last half of June, rather commonly through the first week in July, and one battered specimen the first of August. No larvæ have been taken or food plant determined.

DELTOCEPHALUS REFLEXUS N. SP.

(Pl. xxii, Fig. 1.)

Form very similar to that of *albidus*, but the vertex is longer, narrower and more acutely angled and the elytra more rounding. Light cinereus above, the upper half of the face sharply black, lower half white. Length, 4 to 4.50 mm. Width, 1.75 mm.

Vertex: Length on middle nearly three times that at eye, nearly twice longer than wide, anterior angle acute, tip blunt. Front narrower above than in *inflatus*, facial angle slightly more acute; genæ moderately full, outer angle distinct; loræ only meeting the extreme tip of front, enclosing the clypeus. Pronotum short, truncate behind, posterior angles indefinite; elytra flaring, without an appendix; costal veinlets reflexed, even more strongly than in *albidus*; third apical cell wedge-shaped, twice larger than anal, veins on clavus coalescent through the median third of their length.

Color: Soiled white to light fuscous above; tip of vertex ivory white; triangle with a black margin, line near the margin before the ocelli; rectangular spot on disk, an oblique spot at base of vertex, as in *D. inflatus* well marked, brown. Pronotum soiled white with faint indications of stripes; elytra sub-hyaline, soiled yellowish-white, oblique band reduced to two spots, one on the clavus near the pronotum, the other between the first and second sectors unequally divided by the white cross nervure; apical and reflexed veinlets broadly white, darkly lined before as is also the outer apical margin; tergum broadly black at base, lined near tip; outer pair of lines approximate behind. Below upper half of face sharply black, light arcs more or less distinct; lower half sharply white; venter fuscous.

Genitalia: Ultimate ventral segment of female about half as long as broad, margin roundingly produced in the center, notched. Disk light, produced part black, pygofers broad, short, brown, maculate with white. Male valve broad, obtusely pointed; plates broad at base, concavely, attenuately pointed, three times the length of the valve, equaling pygofers. Described from numerous specimens.

Larvæ resembling those of *albidus* in form and *sayi* in color, but with more definite stripes. Upper half of the face black.

Vertex: Sides acutely angled, point obtusely rounded; body slender, tapering, last abdominal segment, long, narrow. Color above, striped with olive and white, a narrow median white line from tip of vertex to the tip of abdomen slightly expanded on the last segment, a slightly wider light line margining the vertex next the eye on either side and running to the posterior margin of the penultimate segment of the abdomen; a narrow white margin on either side from behind the eyes to the last abdominal segment

The pupæ have a small round spot in the outer light line near the anterior margin of the thorax and a larger oblique mark near the posterior margin of the wing-pads; base of both rows of hairs on the abdomen with small round white spots. Below: Face, upper half black, lower half sharply white, as in adult, the dark line continuing along the fermora and connecting with them as in *abidus* larvæ.

This species and the three following strongly resemble each other. They are most accurately separated by the structure of the genitalia, which have proved to be very constant in the hundreds of specimens studied, as in fact they have for the whole genus, though tested by the study of nearly 5,000 specimens. It has been collected in abundance at Ames this season, and one Colorado example received from Professor Gillette.

It was taken for the first time, June 3rd, when it occurred as full-grown larvæ and adult males. By the middle of June the larvæ had disappeared and the adults were numerous, continuing so well into July. Small larvæ were found the third week in July, and from then on they were numerous until the second week in August, when they had become full-grown and begun to disappear. The adults appeared by the end of the first week in August, becoming abundant by the middle and continuing to

be found throughout the fall. One female, dissected October 26th, showed three fully developed eggs and no smaller ones, probably indicating that the rest had been deposited before then. This species occurs well distributed over the prairies, but has not been found on the field of *Andropogon scoparius*.

DELTOCEPHALUS PECTINATUS N. SP.

(Pl. xxii, Fig. 3)

Form and color nearly of *reflexus*, slightly smaller; vertex distinctly shorter; face all dark. Distinctly separated by the venation and genitalia. Length, 3.50 to 4 mm.

Vertex two and one-fourth times as long as next eye, one-half longer than wide, sides slightly acute, tip nearly pointed; front short, more inflated than in *reflexus*, similar to *albidus;* clypeus short, narrowed at apex, width at base equaling length; loræ broad, sutures strong; pronotum two and one-fourth times wider than long, truncate behind. Elytra less flaring, slightly shorter than in *reflexus;* venation on corium similar; third apical cell smaller or only equaling the anal; veins on clavus not coalescent; abdomen very broad, depressed.

Color: Sordid yellowish-white above, markings as in *reflexus;* the oblique line on anterior margin of vertex nearer edge, less distinct; elytral veinlets not as strongly margined. Below: Face usually all dark, at least no distinct line of separation of color when lighter below; front always dark or fuscous to the base; tergum as in *reflexus;* venter usually darker.

Genitalia: Last ventral segment of the female less than half as long as broad, nearly truncate behind, with four narrow black comb-like teeth; pygofers more than twice as long as breadth at base, maculate; male valve equilaterally triangular, one and one-half times as long as their combined breadth at base, very slightly narrowing, obtusely rounding to truncate behind; shorter than the pygofers. Described from numerous examples.

Larvæ very similar in form and ornamentation to *reflexus;* color, olive green to fuscous, longitudinal stripes less distinctly marked; a white median stripe extending from vertex to tip of abdomen, widening on terminal segment, lateral stripes very obscure, often appearing as dots on the abdomen; body shorter and stouter, vertex shorter and broader, the oblique markings in the pupæ indistinct.

This is a slightly smaller and darker species than *reflexus*, the vertex is less pointed and the elytra inclined to be less flaring, giving it a more compact appearance.

The first adults were taken May 26th, becoming more numerous up to the middle of June, then decreasing in numbers into July. This species had not been recognized as distinct from the preceding until after the time for the first brood of larvæ, so no observations were made upon them. The first larvae recognized as belonging to this species were taken August 4th in a different locality from the preceding, and where *reflexus*

did not occur. They were then nearly grown, and the adults were beginning to appear. Two weeks later the adults were abundant and the larvæ gone. The adults continued abundant until into September, and could be found to the end of the season.

This species was taken wherever *B. hirsuta* was found, and never anywhere else during the season. *B. curtipendula* however usually occurs with *hirsuta* so that it could not be excluded on that ground, but the latter also occurs where *hirsuta* does not, and in no such locations has this species been taken as yet. Within the limits of the area it appears to feed indifferently on either plant, so that if restricted to the one it is probably a restriction of egg deposition.

DELTOCEPHALUS ABBREVIATUS N. SP.

(Plate xxii, Fig. 4.)

Form of *pectinatus* but much smaller. Smaller than *melscheimeri*. Light cinereus in color; length, 3 to 3.25 mm.; width, on center of costa, 1.25 mm.

Vertex shorter than in *reflexus;* slightly, roundingly pointed, twice as long on the middle as next eye, about half longer than breadth between the eyes; front slightly proportionately longer than in *reflexus*, side straight; clypeus longer than broad at base; pronotum very short, truncate behind; elytra variable in length, without an appendix; veins on clavus not united; outer apical cell smaller than anal.

Color, light cinereus, above; markings as in *reflexus* strong; triangle around the white tip complete, broad; oblique line on margin usually reduced to a dot midway between the ocelli and tip; transverse band nearly complete; slightly crescentiform; oblique spots at base of vertex usually strong, sometimes a row of spots near the front margin of the pronotum. Elytra light cinereus, nearly all the nervures fuscous margined; apical cells and anterior margin of reflexed veinlet broadly black margined; tergum dark at base, two apical segments creamy white, with a V-shaped black margin in the female. Below, front fuscous; clypeus, loræ and genæ usually light with fuscous sutures; venter fuscous.

Genitalia: Ultimate ventral segment of the female twice wider than long, slightly emarginate posteriorly; middle fourth produced half its width, truncate, notched; arcuated and dark colored each side of the notch. Male, last ventral segment very short; valve large, acutely angled, much longer than the segment; plates broad, convexly pointed; about twice the length of the valve; pygofers elongate, narrow, much exceeding the plate. Described from numerous examples.

Larvæ: Resembling those of *reflexus* but much smaller in size. Color, olive green to fuscous; dark markings broken up into quadrate areas with fuscous margins. Vertex acutely pointed; body short, broad, abruptly terminated; median line narrow, broadening on the abdomen, where it is obscure; lateral lines usually complete; a transverse line on the vertex,

one-third the way back from the point, white; vertex light margined, except posteriorly.

Pupæ with oblique mark and spot in lateral white line present but obscure. Below, as in *reflexus*, dark marks nearly black.

This is the smallest species of the *reflexus* group; this and its cinereus color will enable one to separate it from *pectinatus* to which its dark face allies it, and which separates it from *reflexus*, or it may be readily separated from either by its genitalia. It has been collected abundantly at Ames, but it is not known from any other locality, although doubtless it will be found to occur with the other members of the *reflexus* group throughout the range of the *Bouteloas*.

Adults and full grown larvæ were first taken in company with the preceding species from *Bouteloa hirsuta* August 4th and 8th, 1896. By the middle of the month larvæ had disappeared, adults continuing numerous throughout the month and on until the middle of September. The spot where this species was found was a high gravelly pasture, the tops and sides of the knolls being covered with this grass, to which it seemed strictly confined.

DELTOCEPHALUS OCELLARIS FALL.

Cicada ocellaris, Fall. Hem. Suec., II, p. 20, 13 (Vide Melichar).

This is a much stouter and darker species than *sayi*, occurring commonly throughout central Europe, and has been received from Colorado. The vertex is much broader than in *sayi;* width between eyes nearly equaling length; pronotum very short; elytra very broad; nervures strong; clavus reticulated, central anteapical usually unequally divided. Color much darker than in *sayi;* light markings on vertex variable, not concentric; face dark, an inverted white T on apex of front; venter and genitalia shining black. Readily separated by the immense, convexly inflated shining black valve and the large, convexly margined plates of the male. Length, 3.50 mm. Width, 1.50 mm. The Colorado specimens were taken by Professor Gillette in Laramie county, July 5th.

DELTOCEPHALUS SAYI FITCH.

(Pl. xxiii, Fig 2.)

Amblycephalus sayi Fitch. Homop. N. Y. State Cab., p. 61.
Jassus sayi Walk. Homop. IV, p. 1158, 1852.
Deltocephalus sayi Uhler. Bull U. S. Geol. and Geog Surv., IV, p. 511, 1878.

This species may be swept sparingly almost everywhere, but occurs throughout the summer in immense numbers on blue grass in woody pastures, either high or low.

The adults are short and compact, with a rounding pointed vertex and broad, almost truncate elytra. In color they are rich brown with the tip and two concentric bands on the vertex lighter, and two bands of lighter on the elytra, one at the base and a broader one back of the middle. On these bands the nervures are distinctly white. In form and ornamentation closely resembling *D flori* Fieb, but readily separated by the genitalia. Length, 3.5 mm.

The larvæ are more elongated than those of *inimicus* and have a narrower and more definitely angled vertex. They are colored very much as in the adult, but the markings are different. There is a narrow median line of white extending from the tip of the vertex to the last abdominal segment, where it broadens and nearly covers the tip; the inner margin of the eyes, a concentric band near the point of the vertex, and two spots just back of the center on either side are lighter. A broad marginal stripe from the eye back, an indistinct, narrow one from the inner margin of the eye, which may break up into white spots, one on the posterior margin of each abdominal segment, and a second row of dots midway between the first and the marginal stripe on either side, complete the white markings of the body. The face is light with fuscous striations.

The larvæ were first taken sparingly from upland prairie the second week in June. They were full-grown and were probably belated ones, as the adults had been taken during the first week. On June 16th the first observation on wooded pastures was made and the adults were swept in immense numbers from rank blue grass. They continued to be found in great numbers whenever observed throughout the remainder of the season. The larvæ were next observed July 11th, when they were somewhat over half-grown, and by the last week in July they were full-grown; abundant, and fresh looking adults were also numerous. Again on the 5th of September nearly full-grown larvæ were observed to be numerous, as also were the adults. Later in the month the larvæ were becoming rare and the adults still very plenty, as they continued to be throughout October. Six females dissected on the 27th of October showed no signs of eggs, from which it might be inferred that they had been deposited. On this assumption, which coincides well with the early appearance of the spring brood of larvæ, the following arrangement of broods would seem very probable and harmonize well with the dates given above.

First brood of larvæ through May and the first week in June, adults from the last week in May until the middle of July; second brood of larvæ, last week in June until the first week in August; second brood of adults from middle of July through

August; third brood of larvæ from middle of August until the last week in September; third brood of adults from the first week in September through October.

DELTOCEPHALUS CONFIGURATUS UHL.

(Pl. xxiii, Fig. 3.)

Bull. U. S. Geol. and Geog. Surv., IV, p. 511, 1878.

This widely distributed species is the largest of the genus in America, and though the coloration is often so faint as to leave it almost unicolorous above, it may be easily recognized by its broad, blunt head as well as by its peculiar genital structure. The last ventral segment of the female terminates in an attenuate bifid black process, and the male plates are strong, broad and obliquely truncate.

In the definitely colored individuals there is a white cross on a white margined vertex of fuscous and alternating light and fuscous stripes on the pronotum. The nervures of the elytra are white, margined more or less strongly with fuscous. The elytra vary in length, usually longer than abdomen. A median impressed black line on the vertex is never entirely wanting. Length, 4.50 to 5 mm. Closely related to *D. bohemani* Zett, but with male plates distinctly shorter, and not laterally excavated.

The larvæ may be separated from *sayi* by the broader head, rounder vertex and stouter form and from any other of the striped larvæ by the fuscous striated front. It is of a pale brown above, with three indistinct stripes and a row of dots just inside the narrow light margin on either side of the abdomen. Front light, with indistinct fuscous striations.

This species was first taken in great abundance as full-grown larvæ and freshly issued adults on May 2nd and 12th. Within two weeks the larvæ had all disappeared, while the adults were very numerous throughout June, and a few were found in July.

This species occurred with *albidus* on the field that was mowed June 25th, and as recorded for that species, was practically exterminated by the process. Though the field was under continual observation throughout the remainder of the season the only indication of a second brood was the sweeping of a half grown larva July 16th. These facts indicate that it has a very similar life-history to *albidus*, the broods however occurring from one to two weeks earlier, the second brood of larvæ probably appearing the last week in June and continuing through July; the second brood of adults from the last week in July

through August, larvæ again appearing sometime in September, going through the winter to appear again as adults in May.

Facts which materially strengthen these conclusions are that while in these two species exterminated, known facts in their life-history indicate that the eggs would have been deposited before this time, and would thus be subject to destruction, while other species occurring on the same area, whose eggs are known to be deposited at other periods, remained abundant throughout the season. That close mowing at the proper time was an effectual check seemed to be thoroughly demonstrated for these two species. There would be a second period, when the eggs of the second brood might be destroyed, occurring, according to the above determinations, toward the last of August.

DELTOCEPHALUS DEBILIS UHL.

(Plate xxiii, Fig. 2.)

Deltocephalus debilis Uhler. Bull., U. S. Geol. and Geog. Surv., II, p. 360, 1876.
Deltocephalus minki Fall. Provancher. Pet. Faun., III, p. 279, 1889.

Although this is a very variable species in color, size and genital characters, and approaches in its different variations three recognized European species, *abdominalis*, Fab., *falleni* Fab., *minki* Fieb., the intergradation of these varieties prevents their separation, for this country at least. An examination of the European material at hand indicates a similar variation in their fauna.

This species may be briefly characterized as follows:

Color, usually deep green, more or less marked with black below, sometimes even appearing on the elytra. Vertex variable, more or less distinctly, acutely angled; length usually slightly greater than width; front strong, broad above; sides straight; loræ long; genæ with the lateral margins excavated below the eyes; outer angle very distinct, scarcely rounding below the clypeus; elytra, length variable, usually exceeding abdomen; venation distinct, central anteapical cell large, first anteapical narrow, elongate, nearly parallel margined.

Genitalia: Ultimate ventral segment of female varying from rounding behind with a deep notch to nearly truncate, slightly lobed each side of a shallow notch. Male valve obtuse, variably exposed; plates very broad at base, slightly longer than wide, bluntly, obtusely pointed, lined or spotted with black; length, 4 mm.

This well known species is comparatively rare at Ames, a few specimens being taken each year. During this season adults were taken from the first week in June until the first week in July, usually found in wooded regions.

DELTOCEPHALUS MINIMUS N. SP.

(Plate xxiv, Fig. 4.)

Form and color of *debilis*, but less than half the size; length of vertex more variable even than in that species; the smallest species in the genus; length, female, 2.75 to 3 mm.; male, 2.25 to 2.50 mm.

Vertex very variable in length, usually convexly and acutely pointed in the female, longer than the pronotum; roundingly rectangular in the male, about equaling the pronotum; front strong; similar to *debilis*, broader on the clypeus; clypeus broad, one-half longer than wide; loræ broad, nearly semi-circular; genæ much narrower than the eyes, lateral margin short and straight.

General color like that of *debilis;* vertex, margins of the pronotum and scutellum yellowish-green; disk of the pronotum and basal part of the elytra dark green; apical portion of the elytra lighter. Below, front fuscous with lighter arcs, rest of face greenish; tergum and venter greenish or fuscous, varying to black; legs usually distinctly black below.

Genitalia: Ultimate ventral segment of female broad; posterior margin roundingly produced from the lateral angles, narrowly arcuated and notched medially, black tipped; pygofers nearly twice as long as width at base, equaling the black ovipositor; male valve large, triangular; plates broad, convexly pointed, three times the length of the valve, usually a dark spot beyond the middle of each. Described from numerous examples.

Larvæ: Small dark green forms with acutely pointed vertices and black faces and eyes; vertex convexly, acutely pointed; body long, tapering from eye back to tip of abdomen; hairs on abdomen distinct; green above, vertex lighter, ocelli black. Below, all dark fuscous to black in the later moults, especially noticeable on legs.

This very small and distinct species occurred abundantly on a patch of raw prairie adjoining the *Adropogon* field, where the *oculatus* occurred so thickly, and was found at the same time and in the same stages as that species throughout the season, but did not occur on the isolated *Andropogon*. *Sporobolus heterolepis* and the *Stipa* were very plentiful, where they were most abundant, either one of which would harmonize well with its green color.

DELTOCEPHALUS MELSCHEIMERI FITCH.

(Plate xxiv, Fig. 1.)

Amblycephalus melscheimeri Fitch. Homop. N. Y. State Cab., p. 61.
Deltocephalus debilis Osborn. Bull, Iowa Exp. Sta. No. 13, p. 100; No. 20, p. 714.
Deltocephalus affinis Gillette and Baker. Hemiptera of Colorado, p. 84.
Deltocephalus auratus Gillette and Baker. Hemiptera of Colorado, p. 85 (Female).

This is a slightly smaller species than *debilis* and with more general fuscous markings.

Vertex one-half longer on middle than at eye, width between eyes greater than length; obtusely, slightly roundingly angled. Front narrower

below than in *minimus;* genæ long, not distinctly angled outwardly. Elytra narrower than in *debilis*, venation similar, outer anteapical cell short, rounding; ultimate ventral segment of female short, truncate behind, usually medially depressed, giving it a strongly, angularly excavated appearance; male valve large, inflated, rounding posteriorly, concealing all but the tip of the short plates. Color varying from pallid, with subhyaline elytra to fuscous, with heavily fuscous margined elytral nervures; tergum venter and male genitalia black; length 3.75 mm.

Larvæ, form of those of *inimicus*, nearly; vertex longer than broad, definitely angled; body stout; abdomen short; color light yellow, much lighter than the dorsal color in *inimicus*, without markings of any kind.

This is a widely distributed and well known species, occurring in immense numbers on blue grass in lawns and open pastures, and frequently met with in various other open situations, never occurring, however, very far within the margin of shaded areas, where it gives place to *sayi* and *Athysanus curtisii.*

Work was not commenced early enough to determine fully the life-history, but broods the past season were recognized on blue grass as follows: Adults from the middle of May until the last of June; larvæ from the first week in June till the middle of July; adults from the first week in July through August; larvæ through August until the middle of September; adults from the middle of September through the season.

It is the only American representative of a series of species with enlarged male valve and concealed plates, and is thus rendered very distinct in our fauna. The closest allied form seems to be the European *D. striatus* L., with similar recorded habits.

DELTOCEPHALUS OCULATUS N. SP.

(Pl. xxiii, Fig. 4.)

Form and size very close to that of *melscheimeri*, slightly smaller, resembling the European *D. metrius* Flor in size and color, but with a sharper vertex. Length, 3.50 mm. Width, .99 mm.

Vertex variable, at least one-third longer than broad, one and one-half times length next eye, convexly pointed; front broad, straight margined; genæ arising from the outer corner of the eye, moderately curved below; elytra long and narrow, similar in form and venation to those of *melscheimeri*, but with nervures less distinct.

General color of the female light yellow; eyes and tip of last segment purplish black; male slightly greenish-yellow; tergum and venter darker front with fuscous arc and in fall broods the vertex is marked with brown.

Genitalia: Ultimate ventral segment of the female short, lateral angles slightly acute, central half of posterior margin narrowly produced; length of produced part equal to its width at apex; apex with three lobes indicated, produced part dark colored; male valve triangular, shorter than broad,

plates broad at base, rapidly, roundingly narrowing to the narrowly produced, black-tipped points. Described from numerous specimens.

Larvæ: Tawny yellow, sometimes with light fuscous marking; a bright purple spot on either eye in life or in freshly mounted specimens; vertex narrow and longer, more acutely pointed than in *melscheimeri;* body narrower, more gradually tapering. In general color is more intense than in *melscheimeri,* and approaches *inimicus;* late or exposed forms sometimes distinctly fuscous marked. Living specimens are readily separated by the distinct purple spot on the eye.

This species has been received from Colorado, and has been collected at Ames prior to this season. It was first taken this year as adults the last week in May, and from then on through July. Larvæ were taken abundantly during the second and third weeks in July, disappearing by the end; adults were again found from the middle of July through August; larvæ again appearing in August, maturing through September; adults from the first of September on through the season.

It has been found everywhere on *Andropogon scoparius*, to which it seems strictly confined. Mowing during the middle of June and again the first half of August, or burning during the fall or spring would serve to check this species.

DELTOCEPHALUS SYLVESTRIS N. SP.

(Pl. xxv, Fig. 4.)

Form and venation nearly of *D. cinereus*, but with a longer vertex. Form and size of the European *repletus*, but differing in venation. Length, 3.50 mm. Width, 1 mm.

Vertex twice as long on the middle as next eye, longer than the pronotum, nearly twice longer than wide, acutely pointed; front long, narrow, much longer than wide, hardly half wider at ocelli than on clypeus; clypeus strong; loræ broad, prominent. Pronotum long, more than half as long as wide; posterior angles strong; elytra long, narrow, nervures distinct, venation as in *debilis*, outer anteapical long, narrow, distinctly more than half the length of the middle one.

Color: Greenish, marked with pale fuscous and brown; vertex light green with two more or less distinct brownish stripes; pronotum green, light margined; elytra greenish, nervures light, more or less fuscous margined; never with a whitish cloud, as in *cinereus;* tergum black at base; front fuscous with light arcs, clypeus light; loræ and genæ with fuscous and light margins.

Genitalia: Ultimate ventral segment of the female light colored, long, slightly narrowing posteriorly; the middle third abruptly produced one-half its width, produced part longer at the margin, not notched or rounded as in *cinereus*, distinctly black; male valve broadly triangular, apex pointed; plates three times the length of the valve, broad at base, concavely pointed, tip divergent, a dark line near the outer margin widened to a spot near the middle.

This is a widely distributed species, having been received from Maryland and Kansas. Specimens are in the VanDuzee collection from Ontario, and it has been taken at Ames for a number of years. It occurs only on blue grass in wooded areas, where it may be found in immense numbers. It was first observed this season, June 4th, in considerable numbers, and from then on nearly through July. Observations were not made again until September, when it was found as thick as ever. The larvæ were not successfully separated from those of other species occurring in the same location and so no separation into broods can be made at present.

DELTOCEPHALUS CINEREUS VAN D.

Trans. Am. Ent. Soc., XIX, p. 304, 1892.

This is a neat, compact little species, slightly stouter in appearance than *melscheimeri* and of a distinctly fuscous or cinereus cast.

The vertex is twice as long on the middle as next eye, length and width about equal, tip acutely produced, pale fulvous brown, with narrow margins and a broader median line enclosing a black impressed line, white; elytra with cinereus nervures, heavily margined with fuscous.

Genitalia: Ultimate ventral segment of female slightly rounding behind, distinctly notched in the center, slightly arcuated and deeply black either side of the notch; male valve produced, sides emarginated, apex obtusely rounding; plates more than twice the length of the valve, convexly pointed.

Specimens of this species have been received only from California, from which place it was originally described. This species and the preceding one are closely allied, but may be readily separated by the length of the vertex and the female genitalia, as well as by the difference in color.

DELTOCEPHALUS AURATUS G. & B.

Hemiptera of Colorado, p. 85.

The female described under this name by Gillette and Baker (Hemiptera of Colorado, p. 85) was evidently a freshly issued example of *melscheimeri* as may be readily determined by comparing his description and drawing with the descriptions and drawings of *D. affinis* on the preceding page of same work, *affinis* being also a synonym of *melscheimeri* as proved by examination of typical specimens of both sexes. The male *auratus*, however, is a very distinct species, with a more roundingly margined vertex, and narrower front and clypeus.

The elytra are very long, overlapping, with a distinct appendix, the center anteapical cell greatly elongate, posteriorly extending much beyond the adjacent cells; valve broad, short, about equaling the ultimate segment; plate broad at base, about three times the length of the valve, slightly narrowing, with straight margins to the broad truncate apex; styles bristle-like, exceeding the plates; pygofers with numerous strong spines below. Color: face and vertex orange red, pronotum and elytra yellow, sometimes with a reddish cast; venter and genitalia light yellow, plates narrowly black-tipped.

DELTOCEPHALUS SIGNATIFRONS VAN D.

(Plate xxv, Fig. 1.)

Trans. Am. Ent. Soc., XIX, p. 305, 1892.
D. sexmaculatus G. & B., Hemip. Col. p. 88.*

This species, which was described from Colorado, and has been received from Maryland, occurs very commonly at Ames. It very closely resembles *inimicus* in form and color, but is readily recognized by its smaller size, and the absence of the dots of the former species.

The adult is 3.50 mm. long, narrow, elytra elongate, closely folded, giving it a very narrow appearance posteriorly. Vertex with six more or less distinctly marked bars, anterior pair smallest; the nervure of the elytra alternately fuscous and lighter; central anteapical cell elongate, constricted, rarely, if ever, divided.

Adults were taken rather commonly May 29th, and again June 4th, no more being taken until the last of August, when they were again swept in fair numbers, and from then on until September 10th, when the last one was taken. They were most abundant upon weedy places, roadsides, etc., where *Setaria* and *Panicum* abound. Considering the nature of the food-plant no economic measures need be suggested, unless it should be found to occur on millet or Hungarian grass.

DELTOCEPHALUS INIMICUS SAY.

(Plate xxiv, Fig. 3)

Jassus inimicus Say. Jour. Acad. Nat. Sci., IV, p. 305, 1831; Compl. Writings, II, p. 382, 1869.

This species is almost universally distributed throughout the northern part of the United States and into Canada. It has previously been reported west to the Rocky Mountains, and

* On examination, the type specimen now in possession of Mr. E. P. VanDuzee proved to be an immature female of this species.

specimens are in hand from the state of Washington. It is readily recognized by its short vertex, elongate elytra, with the central anteapical cell divided, and the presence of six round black dots, a pair on the anterior margin of each, vertex, pronotum and scutellum; color, fuscous maculate. Ultimate ventral segment of the female narrowing posteriorly, margin twice indented, including a median obtuse tooth, outer angles rounding; male, ultimate segment slightly, angularly emaginate; valve short, obtusely angled; plates narrow, acutely pointed, equaling the pygofers.

Larvæ: broad, stout-bodied, with blunt, obtusely rounded heads; color yellow, with a broad, black margin behind the eyes.

The life-history of this species has already been given. Further observations during the past season confirm the idea of two broods as follows: Larvæ appearing about the first of May and maturing before the middle of June; adults from the first of June to the middle of July; the second brood of larvæ appearing before the middle of July and mostly matured by the third week in August, adults again from the second week in August on through September.

This species has a wide range in food habit and consequent variability in its life-history. The limits given above are for blue grass broods, where it is under nearly constant conditions and seems to be reasonably definite in its appearance. Its occurrence on annuals would be materially affected by the date of their appearance.

DELTOCEPHALUS WEEDI VAN D.

(Plate xxv, Fig. 2.)

Trans. Am. Ent. Soc., XIX, p. 306, 1892.

This pretty little species has also, probably, a very wide range, though only reported as yet for Mississippi. It also occurs at Ames.

Adults measuring about 3 mm., with a bluntly produced vertex, sides sharply concave, elytra slightly longer than the abdomen, flaring; central anteapical cell divided, color testaceous brown, with the anterior portion of the vertex and nervures of the elytra light; four dark points on anterior margin of vertex, front and venter dark; male plates short, together nearly circular in outline.

This species was taken at Ames in June, but no determination as to its life-history has been made.

DELTOCEPHALUS COMPACTUS N. SP.

(Pl. xxv, Fig. 3.)

Form and coloration similar to *weedi*, though with a shorter, blunter vertex and shorter elytra. Length, 2.75 mm. Width, 1.25 mm.

Vertex one-half longer on middle than next eye, slightly longer than broad, tip bluntly, slightly, convexly pointed; disc of the vertex slightly rounded; front inflated, broadest in the middle, rounding above and below; clypeus straight; genæ narrow, arising within the middle line of the eyes, scarcely angled; pronotum large, equaling vertex in length, posterior angles strong; elytra strong, convex, about equaling the abdomen in length, nervures strong, white, usually numerous strong reticulations between the outer claval nerve and the suture; central anteapical cell divided, posterior division usually circular in the shorter-winged specimens, resembling *ocellaris* in this respect.

Color: General appearance maculate brown; vertex light yellow with variable black and brown markings as follows: A black crescentiform interrupted band between the front margins of the eyes, a pair of approximate points near tip, and another pair just inside the black ocelli, dark brown; behind the crescentiform band on either side the median impressed black line, a circular light brown spot, which may be emphasized on the lateral margins when they appear as crescentiform dashes; pronotum dark reddish-brown, more or less maculate before; two faint wavy white lines across the disk; scutellum yellowish-brown, two dark spots on the disk; elytra brownish fuscous; nervures broadly white and fuscous; below, dark with white sutures, to black.

Genitalia: Ultimate ventral segment of female deeply, circularly emarginate behind, concealed except the acute lateral angles by a circular subhyaline membrane arising from the base of the segment and extending medially beyond the lateral angle. Male valve small, inflated, rounding posteriorly; plates broad at base, rapidly, concavely narrowing to the long attenuate points, exceeding the pygofers. Described from forty-seven specimens.

This species has been received from the state of Washington and collected at Ames the past season.

Adults were first taken June 27th, when they were swept rather sparingly from two different patches of *Sporobolus hookeri*. They were taken from that time on till July 27th, and then again, probably of a different brood, August 15th and 19th, the latter ones, however, from a different locality, as the first two patches had been mown before that time.

DELTOCEPHALUS FLAVOCOSTATUS VAN D.

Canadian Entomologist, XXIV, p. 116, 1892.

This species was described from Mississippi; specimens are at hand from Ohio, North Carolina and Georgia, and it has been collected at Ames for a number of years and is recorded from

Washington, D. C. This appears to be an abundant form in the south and is apparently reaching its northern limit in Iowa, occurring, however, in marvelous abundance in hot sheltered locations and on southern exposures where the vegetation is short and the ground hot.

The adults are readily recognized by their deep, testaceous brown or black ground color, with a series of points on the anterior margin of the vertex, extending down to the antennal pits on either side and the two outer apical veinlets, white. The legs and a narrow marginal stripe on the basal half of the costa yellow. The head is short and rounding, the elytra long; central anteapical cell divided. Ultimate ventral segment of the female rounding posteriorly, slightly produced in the middle; male valve broad, convex, obtusely, concavely pointed; black, with a narrow yellow margin; plates two and a half times the length of the valve, bluntly pointed, margined with yellow bristles.

Larvæ: Quite as distinctly marked as the adult and are easily separated from any other form. They are two to two and one-half millimeters long, when full-grown, very stout built, head broad and short as in the adult. Color above a rich olive brown with three white bands as follows: One on the posterior margin of the thorax, complete in the larvæ but only visible between the wing-pads in the pupæ, a narrow interrupted one on the middle of the abdomen, and a broader one near the tip; each abdominal segment margined posteriorly with red, just in front of which there are four white dots arranged in longitudinal rows where not obscured by the white markings; eyes, area between the posterior bands and tip of abdomen darker, approaching black; beneath pale, with tip of abdomen and posterior tibiæ darker.

The adults were taken first June 20th, on a field that had just recently been seeded down and on which weeds were springing up very thickly. On July 27th the same spot was abounding in full-grown larvæ, pupæ and adults; the larvæ and pupæ disappearing within a week, adults continuing abundant from then on into and through October.

DELTOCEPHALUS NIGRIFRONS FORBES.

Cicadula nigrifrons Forbes. 14th Rept. Ill. State Ent., p. 67.
D. fusconervosus Van D. Bull. Buffalo Soc. Nat. Sci., V, 207, 1894.
Thamnotettix perpunctata Van D. Bull. Buffalo Soc. N. Sci., V. No. 4, 1894.
Deltocephalus vanduzei Gillette and Baker. Hemiptera of Colorado, p. 90.

The specific limits and generic position of this species are very puzzling and have led to much confusion and synonomy

It has not been thought best at present to change the generic reference given by VanDuzee, although not included in the synopsis. With a more exact definition of the American genera which will be possible as our species are better known, this and some other aberrant forms of a generalized and plastic charac ter may find their proper position.

It was first described by Forbes as a *Cicadula* from specimens with weak venation. VanDuzee received dark specimens of the green form from Mississippi and described them as *Thamnotettix perpunctata;* also describing a strong veined form from California with two cross nervures as, *D. fuscinervosus.* Gillette and Baker, from very dark forms, described *D. vanduzei.*

Larvæ and adults were found in immense numbers about the first of July. The larvæ had mostly all issued by the 10th, the adults continuing through the month; adults were again taken late in September and on into October. They were first found on a patch of plowed ground overgrown with *Panicum sanguinale* and *crus-galli*, and *Setaria viridis.* Here they occurred in immense numbers. They appeared to be more common on the annuals than on the perennials, but were taken almost everywhere, the later ones mainly from blue grass, the annuals having ripened and died. Professor Forbes described it as a serious pest of oats and in Insect Life, vol. VI,. it was recorded as very abundant and destructive in lawn grass in Washington, D. C.

Where first found this season it occurred in two distinct forms about equally common, one with a single cross nervure and long elytra as in *Thamnotettix.* This form was light greenish-yellow with a light face, usually surrounded by an arch of dots above on the anterior margin of the vertex and two oblique dots on the disk of the vertex. The other form was cinereus, darker below, with shorter hyaline elytra, usually with two cross nervures and the central anteapical cell divided. These may probably be regarded as the equivalents of long and short-winged forms in other species, the smaller darker form with the more complex venation, being found almost everywhere, while the lighter form with the weak venation was only found in connection with the larvæ and apparently made little use of the wings.

The specific characters differ very little between the different forms, the variations in genitalia being similar to those in the long and short-winged forms of other species.

The vertex is short, obtusely angled, margins rounding to the front; a row of dark spots on the anterior margin extending down the face to the

antennæ; the spots on the vertex more or less united and merged into bands connecting with the oblique bands on the disk; in the darker forms the front is roundingly inflated, the margins continuous with that of the clypeus; clypeus broadest below. The dark markings on the front heighten this appearance by rounding away from the sutures above on the front and expanding on the clypeus below. While these two forms are fairly constant they so intergrade in structure and color as to render separation impossible. Late specimens of the green form being often similarly marked and even more highly colored than early ones of the fuscous form; while early examples of the fuscous form often possess a venation even weaker than that of the green form and would be readily mistaken for *Cicadula*. Moreover, there is no distinction in the larvæ which produce them.

Larvæ: Form nearly that of *flavocostatus;* slightly narrower and more elongate, approaching those of *exitiosa*. More distinctly yellow than those of *D. ocellaris*, unmarked except two black dots on the margin of the vertex midway between the eye and the tip and a pair of oblique dashes on the disk of the vertex. The pupæ have in addition to these three spots on the anterior margin of the wing-pads and a number on the posterior half of the disk more or less definitely arranged in transverse rows.

A very widely distributed and abundant species. Specimens are at hand from New York, Maryland, Mississippi, Louisiana, Illinois, Iowa, Colorado and California.

DELTOCEPHALUS ARGENTEOLUS UHL.

Delocephalus argenteolus Uhler. Bull. U. S. Geol. and Geog. Surv., III, p. 473, 1877.
Athysanus curtipennis Gillette and Baker. Hemiptera of Colorado, p. 92.
Eutettix terebrans Gillette and Baker. Hemiptera of Colorado, p. 102.

The short-winged forms of this species are very close to the European species of the genus *Doratura*.

D. MONTICOLA G. AND B.

Hemip. Col. p. 88.

This is a good Deltocephalus, but specimens came too late to allow of its insertion in the synopsis. It would follow *D. minimus*, which it closely resembles in size and coloration, but from which it is readily separated by the presence of a distinct median tooth on the last ventral segment of the female.

DELTOCEPHALUS MINUTUS VAN D.

Entom. Amer. VI, p. 96, 1890.

This species was described from a long-winged male, but it occurs in both long and short-winged forms very abundantly. The short-winged examples apparently fall into the genus *Doratura*.

DELTOCEPHALUS OSBORNI VAN D.

Trans. Am. Ent. Soc., XIX, p. 304, 1892.

This species should be placed in *Athysanus* and close to *extrusus*.

DELTOCEPHALUS SIMPLEX VAN D.

Trans. Am. Ent. Soc., XIX, p. 304, 1892.

This and the three following species should be placed in the genus *Thamnotettix.*

DELTOCEPHALUS COQUILLETII VAN D.

Entom. Amer., VI, p. 95, 1890.

D. CONCENTRICUS VAN D.

Deltocephalus concentricus VanDuzee. Bull. Buffalo Soc. Nat. Sci., V, p. 208.
Thamnotettix flavomarginata Gillette and Baker. Hemiptera of Colorado, p. 96.

D. BIMACULATUS G. AND B.

D. bimaculatus Hemiptera of Colorado, p. 86.
D. flavovirens, G. and B. Hemiptera of Colorado, p. 87.

DELTOCEPHALUS UNICOLOROUS G. AND B.

Hemiptera of Colorado, p. 89.

Probably an immature specimen of their *monticola.*

ATHYSANUS CURTISII FITCH.

Amblycephalus curtisii Fitch. Homop. N. Y. State Cab., p. 61, 1851.

This species is the best known and the most widely distributed member of the genus occurring throughout the Eastern States and Canada, and as far west as Michigan and Iowa at least, probably to the mountains. The adult is three and one-half millimeters in length by one and one-half broad, with the vertex scarcely longer than the width of the pronotum, obtusely convexly pointed; elytra exceeding the short ovipositor; color, vertex yellow, with large round spots before the middle, and tip black; face yellow, an oblique black band extending from either eye to the base of the clypeus, then prolonged narrowly to the tip, forming a Y-shaped mark; the pronotum yellowish-green, with a black crescent, anteriorly; elytra dark, nervures yellowish-green.

Larvæ stout, with a large, convexly conical head. Of a deep yellow color, with eyes and antennæ dark. The body is covered with long stout hairs.

This species is confined strictly to blue grass in meadows and wooded pastures, where it rivals *D. sayi* in abundance. First collected this season, June 17th, as adults in abundance; the larvæ were found during July, becoming full grown and issuing as adults by the end of the month. Another brood of larvæ matured during September, the adults continuing through the rest of the season, becoming scarce by the last of October, when a dissected female showed one fully developed egg, the rest probably deposited.

ATHYSANUS BICOLOR VAN D.

Canadian Entomologist, XXIV, p. 114, 1892.

This species was described from Kansas and Mississippi, and had been reported from Iowa under the name *virgulatus Uhl* (a MSS. name). The adults have nearly the same form and size as the preceding species; the vertex is more pointed and the attenuate ovipositor extends beyond the elytra.

In color the females are yellowish green, with two large coalescent spots on the vertex, both margins of the pronotum, the entire claval suture and the tip of the wing black; below, all light. The males have the whole point of the vertex the sutural margin and an oblique band from the anal cell to the center of the costal margin black. Below all black except a band across the middle of the face. It can be readily separated from *curtisii* by the absence of the Y on the face, and the fact that the yellowish-green of the elytra is not confined to the nerves.

The larvæ are very light yellow, sometimes almost white, and the hairs are much smaller and finer than those of *curtisii*, which, otherwise, they closely resemble. They were first taken June 16th, when the first adults of a brood were issuing; larvæ remaining abundant until the end of the month. The adults were very thick until well into July, disappearing before the end; appearing again toward the end of August and through September. They were thickest upon a patch of *Andropogon scoparius*, where it was nearly free from other grasses.

ATHYSANUS OBTUTUS VAN D.

(Plate xxi, Fig. 2)

Canadian Entomologist, XXIV, pp. 115, 156, 1892.

This species was described from Mississippi, and has been received from Kansas and taken at Ames prior to this season. The adults have almost exactly the form and size of *bicolor*, but are readily distinguished by their color. The vertex is lemon yellow, with two round spots just before the middle, and two small, oblique dashes near the base, darker. The remainder of the body is testaceous. Apical cells of the elytra hyaline, enclosing veinlets dark.

The larvæ are light yellow when small, but gradually darken to a chocolate brown in pupa, when they resemble the adults in form. The adults have been taken the last week in April, rather commonly, indicating an adult hibernation, the larvæ appearing in May, maturing the middle of June; the adults

remaining through June and the greater part of July. Full-grown larvæ were found toward the latter part of July and again before the middle of September; adults common throughout the season. This would indicate three broods during the season, the third one hibernating as adults, though the larvæ found in July may have been belated ones of the first brood.

The food plant is *Andropogon scoparius*, and it was not until late in the season that the larvæ of *D. oculatus*, *Athysanus bicolor* and the smaller light ones of *obtutus* could be distinguished. Many confusing records interfere with the accurate determination of the later broods.

ATHYSANUS COMMA VAN D.

Canadian Entomologist, XXIV, 114, 1892.

This species was described from Iowa and has been received from Colorado. The adults are five millimeters long by nearly two broad, with a short flat vertex, color creamy white with four square spots on margin of vertex, two round ones near its base, four stripes on the pronotum, the claval suture black. A broad stripe within and parallel to the costal margin, reaching and covering the apical veinlets, curving back to meet a black stripe on the disk, cinnamon brown.

Larvæ have been referred to this species only with some doubt, and will not be described.

Adults were taken from May 27th until July 9th, most abundantly about the third week in June. They were again taken in August, however, not so abundantly. The spring brood was taken from *Elymus canadensis*, but no fall brood could be found on this plant, those taken in August being taken from *Elymus striatus*. On August 11th three partly grown larvæ resembling the adult except that they had only three stripes instead of four, were beaten from the heads of *Elymus canadensis*. This species is strictly confined to the *Elymus* as a host plant, but might damage other grasses near where it was abundant. Cutting the *Elymus* the first of July would destroy the eggs for the second brood.

ATHYSANUS COLON N SP.

(Pl. xxvi, Fig. 3.)

Form and general appearance nearly as in *comma*, clear, creamy white with dark stripe, occurs in two wing lengths. Length of female, 5 mm.; male, 4.25 mm. Width on costa, 2.25 mm.

Vertex nearly flat, one-half wider than long, shorter than pronotum, obtusely angled before, margin obtuse; front one-third longer than wide, width on clypeus more than half that at ocelli; clypeus narrow, nearly parallel margined; loræ large, wider than clypeus; pronotum more than three times wider than long, obtusely rounding before; side margins, one-half the length of the eyes; elytra occurring in two lengths, a short form in which the apical cells are minute, reaching only to the penultimate segment, this usually associated with rudimentary wings, the long-winged form with fully developed apical cells elytra exceeding the abdomen and associated with fully developed wings; venation simple, inner branch of first sector forked near its middle, making one more anteapical cell than in *comma;* four terminal and two costal cells.

Color: Clear, creamy white with testaceous and black markings as follows: Four quadrate spots on the anterior margin of vertex, the outer pair between the eyes and ocelli, two large round spots near the base of the vertex and a smaller irregular pair on the disk midway between these and the inner marginal pair, black; a small black spot under the base of the antennæ, four equidistant dark brown or black stripes on the pronotum, the inner pair extending across the scutellum; a small dash behind the eye and a stripe just under the lateral margin of pronotum, black; elytra with eight brown stripes, a complete longitudinal stripe just outside the first sector and another next the claval suture, a narrow stripe between the branches of the first sector, a shorter one between branches of its inner fork, a broadly interrupted one between the first and second sectors, a complete median stripe on the clavus, one on the outer, apical half and another on the inner, basal half. The apical cells and the apex of the anteapicals, fuscous margined. Tergum with four black lines posteriorly; pygofers with two round black spots above; connexivum broadly margined on the outside, narrowly on the inside, with black; legs lined and spotted with black.

Genitalia: Ultimate ventral segment of the female with the posterior margin angularly excavated; apex of excavation truncate, sharply notched, black; lateral angles acute; male valve narrow, apex rounding, one-half longer than the ultimate segment; plates slightly broader than valve at base, narrowing to the middle, then parallel margined to the broad truncate apex, twice the length of the value, equaling the pygofers; pygofers with the side margins compressed below, an oblique black mark just back of the margin beneath. Described from numerous specimens collected at Ames, Iowa.

Readily separated from *comma* by the additional fork of the first sector, the spots on the disk of the vertex and the number of stripes on the elytra. Superficially it so closely resembles that species that hitherto specimens have been confused with those of that species.

Larvæ very broad, stout forms; head large, resembling the adult; vertex slightly more pointed; color creamy white, with four brown stripes as follows: An inner parallel pair arising from distinct spots on the apical margin of the vertex and extending to the tip of the abdomen on either side, a pair just inside the margin of the body arising behind the eyes and terminating before the last abdominal segment.

Larvæ were taken from *Stipa spartea* June 4th, and issued in the cages on the 6th. They were found up to June 10th, when they had all issued. Adults were taken through June and late into July, but no second brood appeared, probably owing to the ground having been mowed over June 27th, thus destroying the eggs.

This species was never taken away from *Stipa*, but occurred in such abundance that it over-ran the adjacent grasses.

ATHYSANUS MAGNUS N. SP.

(Pl. xxvi, Fig. 2.)

Form similar to *Athysanus argentatus* Fab., but still larger. The largest species in the genus. Ashy, with transverse light bands on head and pronotum. Length of female, 8 to 9 mm.; width of eyes, 2.50 to 3 mm.; male smaller.

Head wider than the pronotum, short, scarcely exceeding half its length; anterior and posterior margins nearly parallel; ocelli distant from eyes; vertex four times wider than long; front four times as wide at ocelli as on clypeus, widest at antennæ; antennæ small, short, inserted under a small ledge; clypeus spatulate; genæ broad; pronotum nearly three times wider than long; elytra strong, broadest at base, without an appendix, two ante-apical cells nearly equal in size, four terminal cells and one costal cell.

Color: Vertex light yellow with an arcuated line between the ocelli; face finely irrorate with brown, becoming darker below; antennal pit black; pronotum fuscous, margins darker, a broad light yellow transverse band just before the posterior margin; elytra, nervures brown, margined with light, disk of the cells finely irrorate with fuscous, costal margin broadly cream colored: tergum with a dark median stripe; venter brownish; femora mottled with brown; tibiæ black lined.

Genitalia: Ultimate ventral segment of female slightly longer than penultimate, strongly notched in middle, broadly, rather acutely lobed either side, lateral angles rounding, slightly exceeding median lobes; male valve small, triangular, one-half the length and two-thirds the width of the ultimate segment; plates together long triangular, about one-half longer than breadth at base, margins thickened and fringed with stout hairs. Described from twenty specimens.

It has been received from Texas, Kansas, Nebraska, Dakota, and northwest Iowa, also collected sparingly at Ames, from *Spartina cynosuroides* exclusively.

CHLOROTETTIX SPATULATA N. SP.

(Plate xxvi, Fig. 4.)

Intermediate, in form and size betwcen *unicolor* and *galbanata* but more distinctly green than in either species. Length, 7 mm; width, 1.75 mm.

Vertex two and one-half times wider than long, margins parallel or slightly longer on middle than next eye, anterior margin broadly rounding

to the face; front narrowing rapidly to the small clypeus; genæ broad, rounding below; pronotum one-half longer than vertex, emarginate behind; side margins short, not strongly carinated; elytra broader than in *lusoria*, venation similar, weak.

Color: Green; elytra sub-hyaline sometimes pallid.

Genitalia: ultimate ventral segment of female very long on lateral margin, posterior margin produced, broadly notched, more than one-half the depth of the segment, apex of notch with a spatulate process two and one-half times as long as breadth at base, two-thirds the length of the notch, lateral margin of segment rounding to the acute lateral angles. Male valve appearing as a narrow margin to the ultimate segment; plates sloping, broad at base, convexly rounding, acutely pointed, about equaling the pygofers.

Described from forty-two examples collected at Ames, Iowa. It has also been received from Colorado (Gillette) and Nebraska (Bruner).

THAMNOTETTIX LUSORIA N. SP.

Form and general appearance of *Chlorotettix tergatus*, but with a sharper vertex and more general reddish cast. Length, 7 to 8 mm; width, 2 mm.

Vertex slightly convex, one-half longer on middle than next eye, twice wider than long, margins broadly rounded, but with a distinct, slightly produced tip; front one-third longer than wide, three times wider at ocelli than on clypeus; pronotum long, front margin strongly rounding, posterior margin nearly truncate, sides long, carinated; scutellum with a quadrate light area on the disk, including two dark spots; elytra two and one-half times longer than wide, much exceeding the abdomen, without an appendix, first anteapical long, parallel margined.

Color: Similar to *Chlorotettix necopina;* vertex olive brown with a faint crescentiform band before the eyes; pronotum fulvous brown; elytra sub-hyaline with a distinct reddish tinge, nervures light; below tawny yellowish.

Genitalia: Ultimate ventral segment of female long, slightly emarginate behind, with a strong, angularly pointed, dark margined median tooth about equalling the acutely rounding lateral angles; pygofers long and narrow, nearly half the length of the abdomen; male valve very short and broad, less than half the length of the ultimate segment; plates strong, flat, one-half longer than breath at base, outer margins thickened, sparsely hairy, points strongly divergent, usually a fuscous line on either side arising from a spot at the base.

Described from eight males and ten females all collected at Ames, Iowa.

THAMNOTETTIX LONGULA G. AND B.

Hemiptera of Colorado, p. 97.

Form of *lusoria* but much smaller; coloration similar to *T. tenuis* Germar. Length, 5 to 6 mm; width, 1.40 mm.

Vertex twice wider than long, slightly longer on middle than at eye, margin rounding, tip slightly produced, front twice wider at ocelli than on clypeus, base of suture rounding; clypeus broadest at the tip; pronotum one-half longer than vertex, slightly concave behind lateral margins, short, rounding; elytra as in *lusoria*, central anteapical cell constricted.

Color: Fulvous maculate with dark chestnut, vertex light fulvous, ocelli white, connected by a light line which runs forward on the tip; a round spot on either side at the base of vertex and a median line, extending forward to the white transverse line, chestnut; front fulvous with dark sutures and abbreviated arcs along the lateral margins dark chestnut; remainder of the face pale yellow with dark figure; pronotum fulvous with the anterior margin maculate with chestnut and bright yellow; scutellum fulvous with a quadrate light-yellow area on disk containing two round chestnut spots; elytral nervures light, chestnut-margined.

Genitalia: Ultimate ventral segment of female twice wider than long, posterior margin slightly notched, much depressed in the middle, giving it the appearance of being angularly excavated; pygofers very narrow, long, strongly spined; male valve broad, about equaling the ultimate segment in length; plates broad at base, convexly rounding, with stout spines to the nearly parallel margined attenuate, unarmed tips.

Described from two males and three females. Collected at Ames, Iowa. One specimen received from Douglass county, Kan. (Kellogg).

[NOTE —Since writing this as the description of a new species, an examination of the Gillette and Baker type has enabled us to refer our specimens to their species. As their description was from male alone, we have thought best to allow our description, which covers both sexes, to stand as sent to printer.]

THAMNOTETTIX PERSPICILLATA N. SP.

Form of *longula* nearly, but much smaller; elytra hyaline with numerous black spots; length, 3.50 to 4 mm.; width, .9 mm.

Vertex scarcely wider at base than long, little longer at middle than on eye, evenly rounding to front: front inflated, long, roundingly narrowing to the small clypeus; clypeus broadening at apex; genæ distinctly angled, nearly straight margined below; pronotum slightly longer than vertex, lateral margins obsolete, posterior angles approaching right angles; elytral venation strong, similar to *longula*, appendix distinct.

Color: Pearl gray; ocelli large, white; vertex light cream color, washed with orange; two approximate oblique dashes on the tip, continuing as lines to the ocelli, and a round spot just behind either ocellus, black; a double median light brown line deflected to either side, just before the middle, forming two chestnut crescents on the disk; basal half of the disk on either side, with a large fulvous ring, enclosing a white spot; pronotum gray, with six white-margined, black spots, arranged in pairs on the anterior margin; scutellum pale yellow, with about five black spots; elytra milky, sub-hyaline, with a fulvous iridescence; nine black spots on each elytron, as follows: Three equidistant small spots on the sutural margin, a spot on the

base of clavus, one on the claval suture one-third the distance from the base to apex, a spot on each of the two apical veinlets, a large spot on the disk of corium between the first and second sectors, and another large one on the sutural margin before the median small dot; front gray, with a median white line, and white arcs, the upper pair forming an arch above the rest, nearly transverse; rest of face light, a black spot under each ocellus and one on either side of the antennal base; tergum light yellow, disk clouded with dark, a row of black spots on either margin; connexivum and venter each with a row of spots next the suture; legs maculate.

Genitalia: Ultimate ventral segment of the female one-half longer on lateral margin than penultimate, posterior margin angularly produced. one-third the length of segment; male valve broad and short; plates broad at base, narrowing rapidly to beyond the middle, with produced attenuate points, one-half longer than width at base, margin stout, fringed with long curved hairs, an oblique black mark on either side at base.

Described from two females and four males, Ames, Iowa.

PHLEPSIUS ALTUS N. SP.

(Plate xxvi, Fig. 5.)

Form similar to *superbus*, short and stout, elytra somewhat flaring: head short and broad, similar to *truncatus*. Dark fulvous brown; length, 5.50 mm; width, 2 mm.

Head slightly wider than the pronotum; vertex scarcely one-third longer at middle than next eye, three times wider than long, less than one-half the length of the pronotum, rounding to the front with a faint carina, as in *cinereus;* front three times wider above than on clypeus, twice longer than wide, slightly expanded below; loræ large, nearly twice wider than clypeus pronotum two and one-half times wider than long, lateral margins very short, less than one-half the length of the vertex, posterior angle well marked; elytra broad, about twice longer than wide, without an appendix, veins on clavus but slightly approaching each other in the middle, seldom with a cross nervure central apical cell no longer than breadth on margin.

Color: Dark fulvous; pronotum and scutellum soiled yellowish-white; irrorate with fulvous brown, disk of pronotum usually clouded with fuscous; vertex and face yellow, finely irrorate, almost clouded with fulvous, usually without pattern of marking except the white margined ocelli and a white spot on the upper angle of the loræ; elytra pearly white, washed with yellowish and irrorate with dark fulvous, except for numerous spots, venter yellowish-brown; legs brown with dark markings.

Genitalia: Ultimate ventral segment of female longer than penultimate; middle half of posterior margin truncate, with a deep median slit and a minute lobate indenture on either side; lateral half of either side produced as a semi-circular lobe against the side of the pygofers; male valve large, longer than ultimate segment, broadly lobate, margin indented on either side of the apex; plate broader than the valve, rapidly, convexly narrowing to the middle, then slightly produced, roundingly pointed; ventral surface convex, disk apparently raised, lighter. Described from sixty specimens.

This species has been collected at Ames and Little Rock, Iowa, and specimens are at hand from West Point, Neb.

(Bruner). It belongs to the group of Phlepsids with the head as broad as the pronotum, but may be readily separated from all the other species of the group by its stouter form and flaring elytra, as well as by the genitalia.

PHLEPSIUS MAJESTUS N. SP.

(Plate xxvi, Fig. 6.)

Form of *spatulatus*, nearly, but larger, with much longer elytra; color distinctly reddish brown with copper reflections; length, 9 to 10 mm.; width on costa, 3 to 3.50 mm.

Head much narrower than the pronotum; vertex, flat, twice wider than long, one-fourth longer on middle than next to eye; front much narrower than in *spatulatus*, very nearly twice longer than wide, basal suture obsolete; clypeus broadly spatulate, twice wider at apex than on middle of loræ; pronotum fully twice longer than vertex, anterior margin strongly produced, lateral margin as long as the vertex, carinate, strongly oblique; elytra long and narrow, much exceeding the abdomen, veins on clavus converging, united by a cross nervure, apical veinlets curved, central apical cell one-half longer than breadth at apex; a number of extra veinlets from the first anteapical cell to the costal margin, reticulations very strong, appearing almost as nervures; closely mimicing the appearance of *Gypona octo-lineata* in this respect.

Color: Cuprescent; vertex light yellow, with two approximate dots near its tip; a broad black band between anterior half of eyes, straight-margined in front, excavated either side of the middle, behind, and often interrupted medially with brown, and a spot on either side of base near eye brown; face pale yellowish, sutures and about nine abreviated arcs fuscous; pronotum fulvous with lateral margins, a Y-shaped mark behind either eye and numerous minute maculations on the disk, creamy white; scutellum fulvous yellow, disk with two brown spots, margin with alternate dark and light markings; elytra yellowish white, nervures and coarser irrorations, fulvous brown; tergum and venter yellowish, dark on the disk; legs yellow; anterior coxæ with large brown spots; femora and hind tibiæ with a series of minute, black dots.

Genitalia: Ultimate ventral segment of the female broader than in *spatulatus*, lateral margins nearly straight, angles rounding, posterior margins roundingly emarginate either side of two large, divergent, acute points, which extend beyond the lateral angles, and are separated by a broad deep notch extending over half way to the base; male valve roundingly produced apex broad, nearly equaling the ultimate segment in length; plates rather narrow, elongate, three times the length of the ultimate segment. Described from five females and four males.

Two females of this species were included by Mr. Van Duzee in his description of *spatulatus* remarking, however, that they were larger and fulvous brown in color and might easily be mistaken for Gyponas. A larger series of both species show them to be decidedly distinct. *Spatulatus* is much

smaller, nearly cinereus in color and has much finer irrorations on the elytra. Specimens are at hand only from Texas, Arizona and California, indicating a southwestern distribution; *majestus* is much larger, fulvous red with coppery reflections, being the largest and most highly colored species of the genus. It closely mimics *Gypona scarlatina* in size and appearance, and occurs in similar situations. Specimens have been collected at Ames, and one specimen received from Philadelphia and another from Mississippi. None have been received from the known habitat of *spatulatus* and it would seem to be an eastern form although its scarcity in collections may be due to the fact that it is extremely difficult to catch.

PHLEPSIUS DECORUS N. SP.

(Plate xxvi, Fig. 7.)

Form very broad and short; elytra flaring; color milk-white, sparsely irrorated with deep fuscous or black giving it a dark, maculate appearance with scarcely a trace of fulvous. Length, 6 mm; width, on center of costa, 2.50 to 3 mm.

Head narrower than the pronotum; vertex flat, similar to *majestus*, twice wider than long, slightly longer on middle than next eye, acutely angled with the front; front broad, flat, sides straight, twice wider above than at apex, about one-third longer than wide, basal suture well marked; genæ broad, outer angle distinct; pronotum short, about half longer than the vertex; lateral margin oblique, carinate, two-thirds the length of the vertex, posterior angle well marked; elytra short, scarcely twice longer than wide, veins on clavus nearly touching in the middle, united by a short cross nervure, central apical cell half longer than wide.

Color: Vertex pearly white with numerous fuscous irrorations which merge into an irregular transverse band between the eyes; face creamy white, irrorate with fuscous, the arcs nearly obliterated; clypeus fuscous on suture, two slightly divergent lines on disk; pronotum yellowish with fine fuscous irrorations, two crescentiform dashes near the anterior margin, black; scutellum soiled yellowish, two fuscous spots on the disk; elytra milk-white, nervures black, claval suture and margins of the nervures yellowish brown, irrorations fuscous to black, more or less definitely arranged in three transverse bands and a series of spots on the costal margin toward the apex; scutellar and sutural margins broadly white.

Genitalia: Ultimate ventral segment of female very broad and short, over four times wider than long, nearly truncate behind with a broad deep notch, extending half way to the base. Male: valve small triangular; plates broad, short and convex, scarcely half longer than ultimate segment, parallel margined at base, bluntly angularly pointed.

Described from one male from Lincoln, Neb. (Bruner), and one female collected at Ames, Iowa.

This and the preceding species belong to the section of the genus in which the head is narrower than the pronotum and which

includes *spatulatus*, *ovatus*, *excultus*, *superbus* and *neomexicanus*. They may be readily separated from the other members of the group by their more definite colors as well as by their distinct genitalia.

ADDITIONS TO THE FORMER LISTS OF IOWA SPECIES.

The following list embraces the additions, not included in the preceding notes, that have been made to the Iowa fauna during the past year or two.

HETEROPTERA.

Perillus exaptus Say. This handsome species has been taken at Little Rock, Lyon county, and Ames.

Podisus serieventris Uhl. Ames.

Oebalus pugnax Fab. This peculiar southern form was taken at Ames in some numbers the past summer.

Lioderma belfragii Stal. A single specimen of this species has been taken by Mr. Ball at Little Rock, Lyon county.

Alydus conspersus Montandon. This name should replace that of *Alydus ater* in previous list.

Neides muticus Uhl. Ames, Iowa.

Belonochilus numenius Say. Ames; not commom.

Ilnacora divisa Reut. Ames.

Phytocoris colon Say. Ames.

Coriscus punctipes Reut. Ames; common.

Coriscus inscriptus Kby. Ames.

Pygolampis sericea Stal. Ames; rare.

Barce annulipes Stal. Iowa City and Ames.

Ranatra quadridentata Stal. Common; *fusca* is less common if, indeed, it occurs in the state.

HOMOPTERA.

Ulopa canadensis Van D. Ames; rare.

Bythoscopus distinctus Van D. Common on Hackberry at Ames.

Idiocerus crataegi Van D. Ames.

Agallia novella Say. Ames.

Pachyopsis robustus Uhl. Not common.

Oncometopia limbata Say. Little Rock and Hampton.

Tettigonia similis Woodworth. Common at Ames.

Diedrocephala angulifera Walk. Ames and LeClaire.

Gypona scarlatina Fitch. Ames.

Gypona albimarginata Woodworth. Ames.

Strongylocephalus agrestis Fall. Ames; rare.

Paramesus vitellinus Fitch. Ames.

Athysanus extrusus Van D. Ames.

Doratura argenteola Uhl.

Doratura minuta Van D. Ames.

Athysanus plutonius Van D. Ames.

Athysanus gammaroides Van D. Ames; not common.

Athysanus striatulus Fall. Ames.

Eutettix lurida Van D. Ames.

Eutettix southwicki Van D. Ames.

Eutettix johnsoni Van D. Ames; rare.

Phlepsius humidus Van D. Ames.

Phlepsius incisus Van D. Ames.

Phlepsius truncatus Van D. Ames.

Phlepsius cinereus Van D. Ames. Fairly common in 1896, but probably a southern form.

Phlepsius fuscipennis Van D. Ames; not common.

Scaphoideus intricatus Uhl. Ames; rare.

Scaphoideus luteolus Van D. Ames.

Scaphoideus lobatus Van D. Ames.

Scaphoideus scalaris Van D. Ames. Hitherto credited only to California.

Scaphoideus auronitens Prov. Ames.

Thamnotettix inornata Van D. Ames. Hitherto recorded for New York only.

Thamnotettix longiseta Van D. Ames. Originally described from Colorado.

Thamnotettix smithi Van D. Ames. Hitherto recorded only from New Jersey.

Thamnotettix fitchi Van D. Ames.

Chlorotettix galbanata Van D. Ames; common.

Gnathodes abdominalis Van D. Ames.

Gnathodes impictus Van D. Ames.

Cicadula variata Fall. Ames.

Cicadula punctifrons Fall. Ames.

Kybos smaragdula Fall. Ames.

Dicraneura abnormis Walsh. Ames.

Dicraneura flavipennis Fab. Ames; common.

Empoasca obtusa Walsh. Ames.

Clastoptera xanthocephala Germ. Ames.

Monecphora bicincta Say. Ames.

Stenocranus croceus Van D. Ames.

Liburnia vittatifrons Uhl. Not common except in particular locations.

Scolops grossus Uhl. Common in 1896.

Vanduzea arcuata Godg. Occurs on locust and usually very abundant where found, Ames and Albia.

Telamona godingi Van D. Ames. Not common.

Stictocephala lutea Walk. Common. Confused with inermis.

Publilia modesta Uhl.

Diaspis rosæ. Muscatine. Very abundant and destructive to roses and other garden shrubs. A serious pest where it occurs.

Hæmatopinus pedalis Osb. An interesting parasite of sheep, occurring on the feet and lower part of legs, but not on wooly parts of the body.

Euhæmatopinus abnormis Osb. A very peculiar parasite of the common mole *Scalops argentatus*. The femora of the hind legs bear disk-like processes which evidently oppose the tibiæ of the middle legs as a clasping organ. I have described it in a bulletin on "The Insects Affecting Domestic Animals," recently issued by the Div. Ent. U. S. Dep. Agriculture.

EXPLANATION OF PLATES.*

PLATE XIX.

Fig. 1. *Xerophloea viridis* Fab. *a*, female, dorsal view; *b*, face; *c*, lateral view; *d*, larva; *e*, male; *f*, female, genitalia.

Fig. 2. *Xestocephalus coronatus* n. sp. female, dorsal view.

Fig. 3. *Euacanthus acuminatus* Fab. *a*, female; *b*, larva, dorsal views.

PLATE XX.

Fig. 1. *Dorycephalus platyrhynchus* Osb. *a*, female; *b*, male, dorsal view; *c*, face; *d*, female, *e*, male genitalia; *f*, eggs in grass stem; *g*, eggs enlarged; *h*, eggs with larva nearly ready to hatch; *i*, newly hatched larva; *j*, larva after first moult; *k*, after second moult; *l*, pupa.

Fig. 2. *Hecalus lineatus* Uhl. *a*, female; *b*, male, *c*, larva, dorsal view; *d*, face; *e*, female, *f*, male genitalia.

PLATE XXI.

Fig. 1. *Parabolocratus viridis* Uhl. *a*, male; *b*, female; *c*, mature larva, dorsal views; *d*, female; *e*, male genitalia; *f*, eggs in grass stem; *g*, eggs enlarged; *h*, single egg much enlarged, showing young; *i*, larva newly hatched; *j*, after first moult.

Fig. 2. *Athysanus obtutus* Van D. *a*, ventral; *b*, lateral; *c*, dorsal view of female; *d*, female; *e*, male, genitalia; *f*, pupa; *g*, eggs much enlarged; *i*, eggs in place under grass leaf sheath.

PLATE XXII.

Fig. 1. *Deltocephalus reflexus* n. sp. *a*, dorsal view; *b*, face; *c*, vertex and pronotum; *d*, female; *e*, male, genitalia; *f*, wing; *g*, larva; *h*, face of larva.

* All figures here given are photo-reproductions of drawings made by Miss Charlotte M. King, under the personal direction and supervision of the authors.

In plates xxii to xxv four species are shown on each plate, each one occupying one-fourth of the plate, and being lettered independently, and in nearly every case the letters correspond for each species, notice of which will avoid any possible confusion in reference to figures.

Fig. 2. *D. inflatus* n. sp. *a*, dorsal view; *b*, face; *c*, vertex and pronotum; *d*, female; *e*, male, genitalia; *f*, wing; *g*, abdomen of male, lateral view.

Fig. 3. *D. pectinatus* *a*, dorsal view; *b*, face; *c*, vertex and pronotum; *d*, male, *e*, female, genitalia; *f*, wing; *g*, larva.

Fig. 4. *D. abbreviatus* n. sp. *a*, dorsal view; *b*, face; *c*, vertex and pronotum; *d*, female, *e*, male, genitalia; *f*, wing; *g*, larva.

PLATE XXIII.

Fig 1. *D. albidus* n. sp. *a*, dorsal view; *b*, face; *c*, vertex; *d*, female, *e*, male, genitalia; *f*, wing; *g*, larva.

Fig. 2. *D. sayi* Fh. *a*, dorsal view; *b*, face; *c*, vertex and pronotum; *d*, female, *e*, male, genitalia; *f*, wing; *g*, larva.

Fig. 3. *D. configuratus* Uh. *a*, dorsal view; *b*, face; *c*, vertex and pronotum; *d*, female, *e*, male, genitalia; *f*, wing; *g*, larva.

Fig. 4. *D. oculatus* n. sp. *a*, dorsal view; *b*, face; *c*, vertex and pronotum; *d*, female, *e*, male, genitalia; *f*, wing; *g*, larva.

PLATE XXIV.

Fig. 1. *D. melscheimeri* Fh. *a*, dorsal view; *b*, face; *c*, vertex and pronotum; *d*, female, *e*, male, genitalia; *f*, wing; *g*, larva.

Fig. 2. *D. debilis* Uh. *a*, dorsal view; *b*, face; *c*, vertex and pronotum; *d*, female, *e*, male, genitalia; *f*, wing; *g*, lateral view of head.

Fig. 8. *D. inimicus* Say. *a*, dorsal view; *b*, face; *c*, vertex and pronotum; *d*, female. *e*, male, genitalia; *f*, wing; *g*, larva.

Fig. 4. *D. minimus* n. sp. *a*, dorsal view; *b*, face; *c*, vertex and pronotum; *d*, female, *e*, male, genitalia; *f*, wing; *g*, larva.

PLATE XXV.

Fig. 1. *D. signatifrons* Van D. *a*, dorsal view; *b*, face; *c*, vertex and pronotum; *d*, female, *e*, male, genitalia; *f*, wing.

Fig. 2. *D. weedi* Van D. *a*, dorsal view; *b*, face; *c*, vertex and pronotum; *d*, female, *e*, male, genitalia; *f*, wing.

Fig. 3. *D compactus* n. sp. *a*, dorsal view; *b*, face; *c*, vertex and pronotum: *d*, female, *e*, male genitalia; *f*, wing.

Fig. 4. *D. sylvestris* n. sp. *a*, dorsal view; *b*, face; *c*, vertex and pronotum; *d*, female, *e*, male, genitalia; *f*, wing.

PLATE XXVI.

Fig. 1. *Platymetopius cinereus* n. sp. dorsal view 1*a* larva.

Fig. 2. *Athysanus magnus* n. sp. dorsal view.

Fig. 3. *Athysanus colon* n. sp. dorsal view. 3*a* wing, 3*b* larva.

Fig. 4. *Chlorotettix spatulata* n. sp. dorsal view 4*a* female, ultimate ventral segment.

Fig. 5. *Phlepsius altus* n. sp. female ultimate ventral segment 5*a* male genitalia.

Fig. 6. *Phlepsius majestus* n. sp. ultimate ventral segment of female, 6*a* genitalia of male.

Fig 7. *Phlepsius decorus* n. sp. ultimate ventral segment of female, 7*a* genitalia of male.

NOTES ON THE ORTHOPTEROUS FAUNA OF IOWA.

BY E. D. BALL.

As a family the Orthoptera have long been regarded as among the most injurious insects of the state. Every addition, therefore, to a list of species adds one more to the number of possible depredators of a given locality. On the other hand, every fact in regard to distribution, life-history or food habits of a species, added to the general knowledge, aids in formulating successful methods of treatment for the particular species.

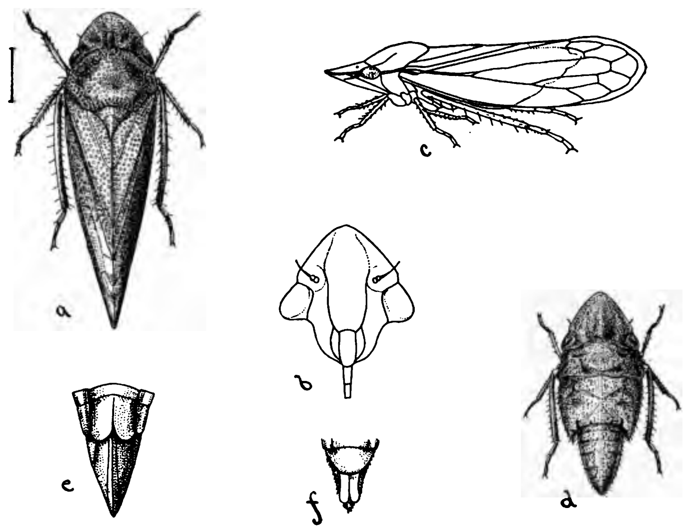


Fig. 1

Fig. 2

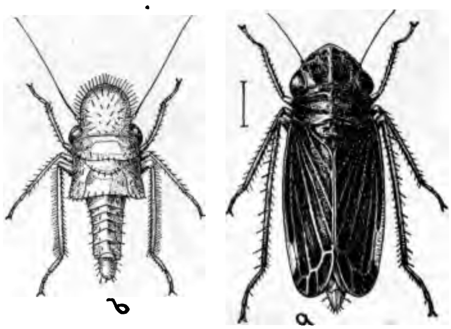
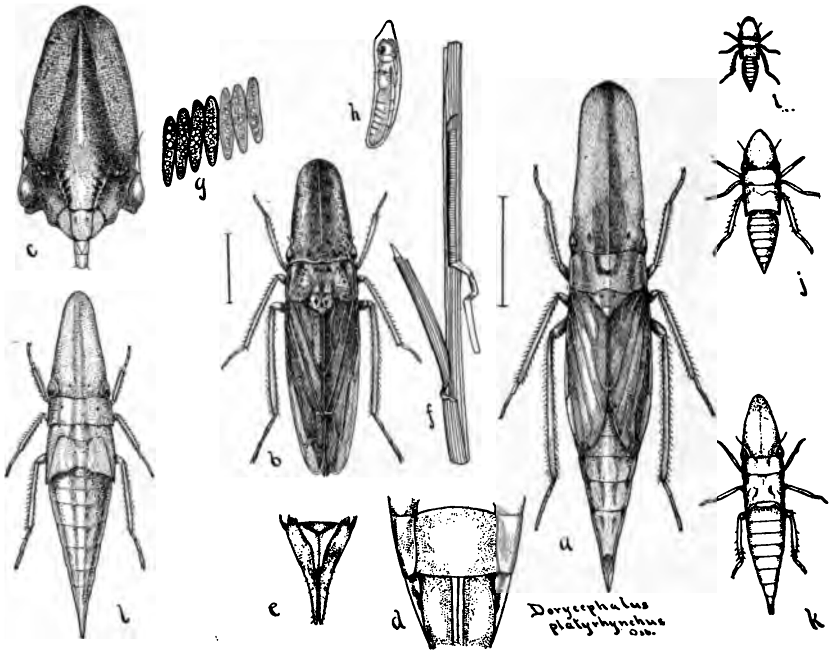
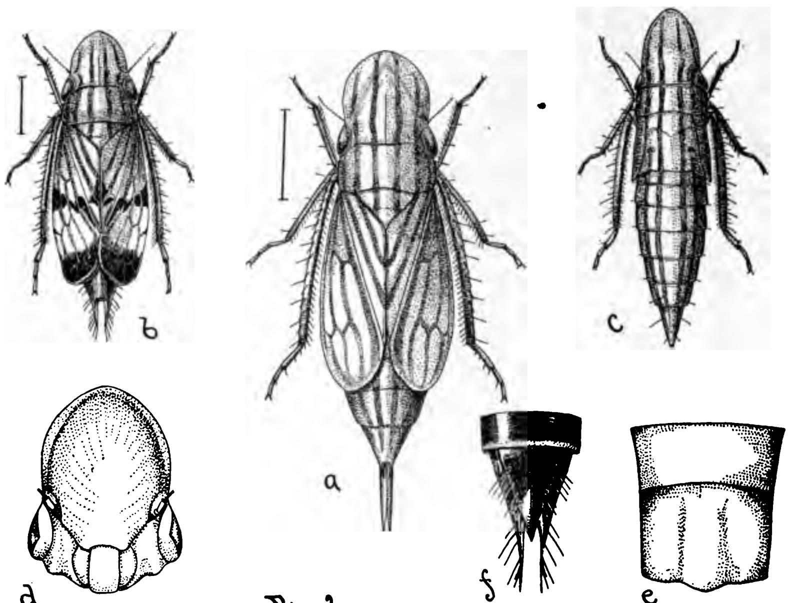


Fig. 3

Fig. 1.—*Xerophloea viridis.* Fig. 2.—*Xestocephalas coronatus.* Fig. 3.—*Euacanthus acuminatus.*





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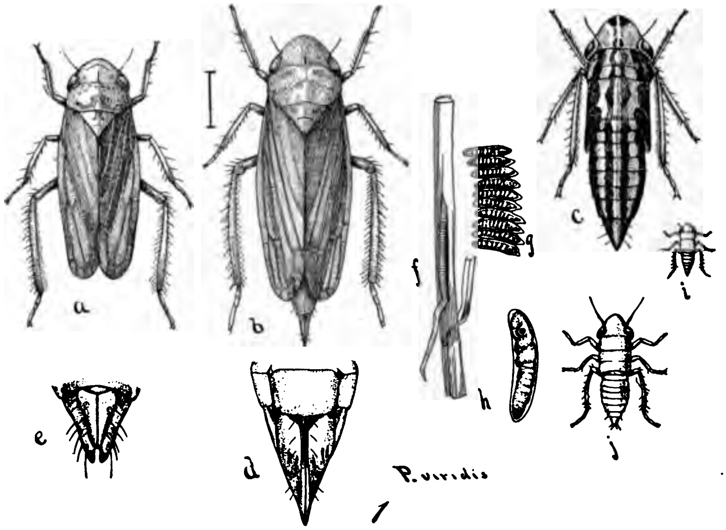
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P. viridis
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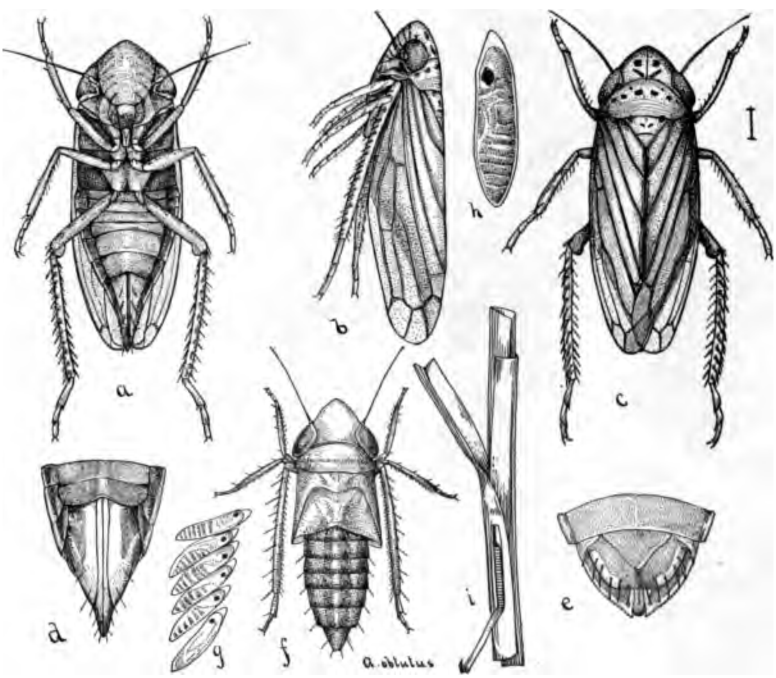
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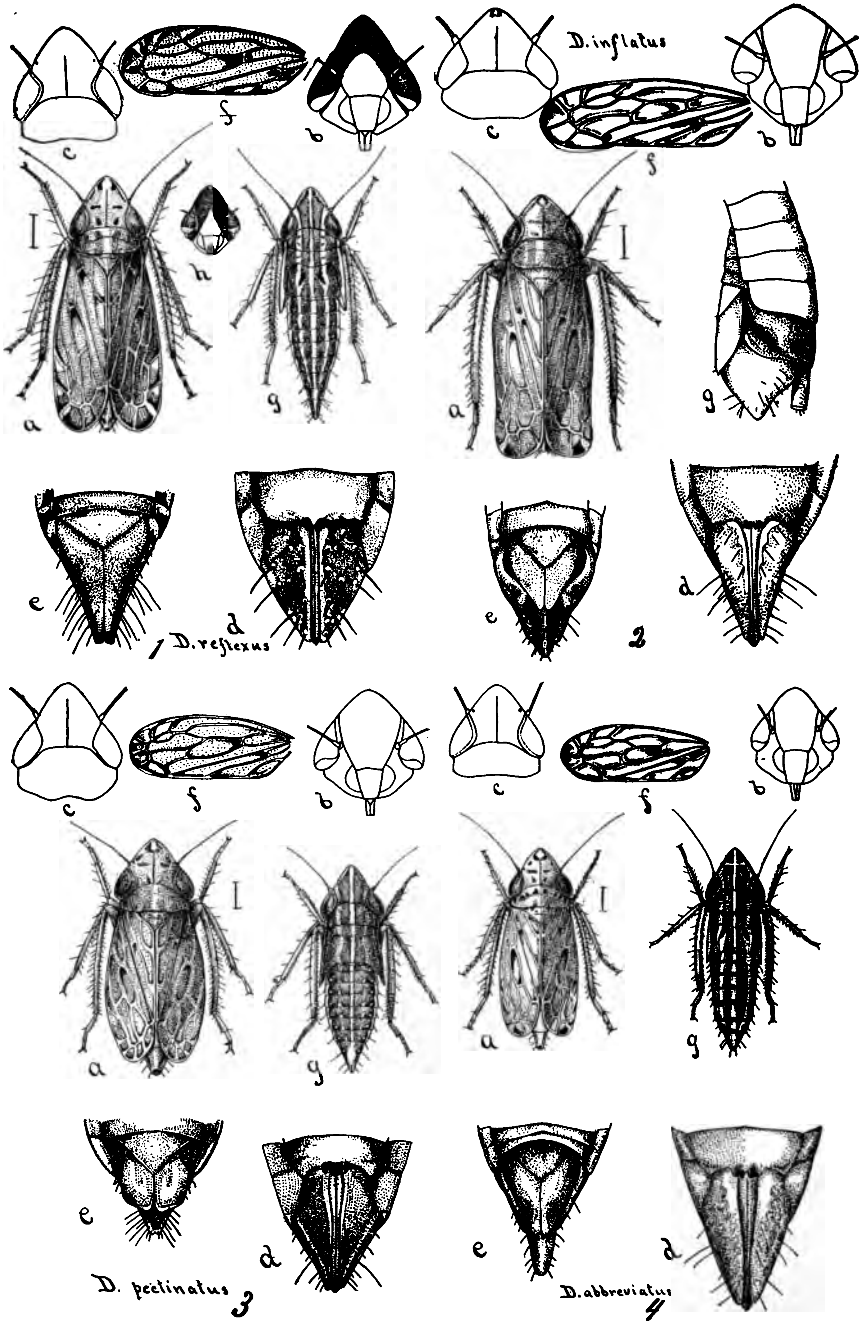
A. obtusus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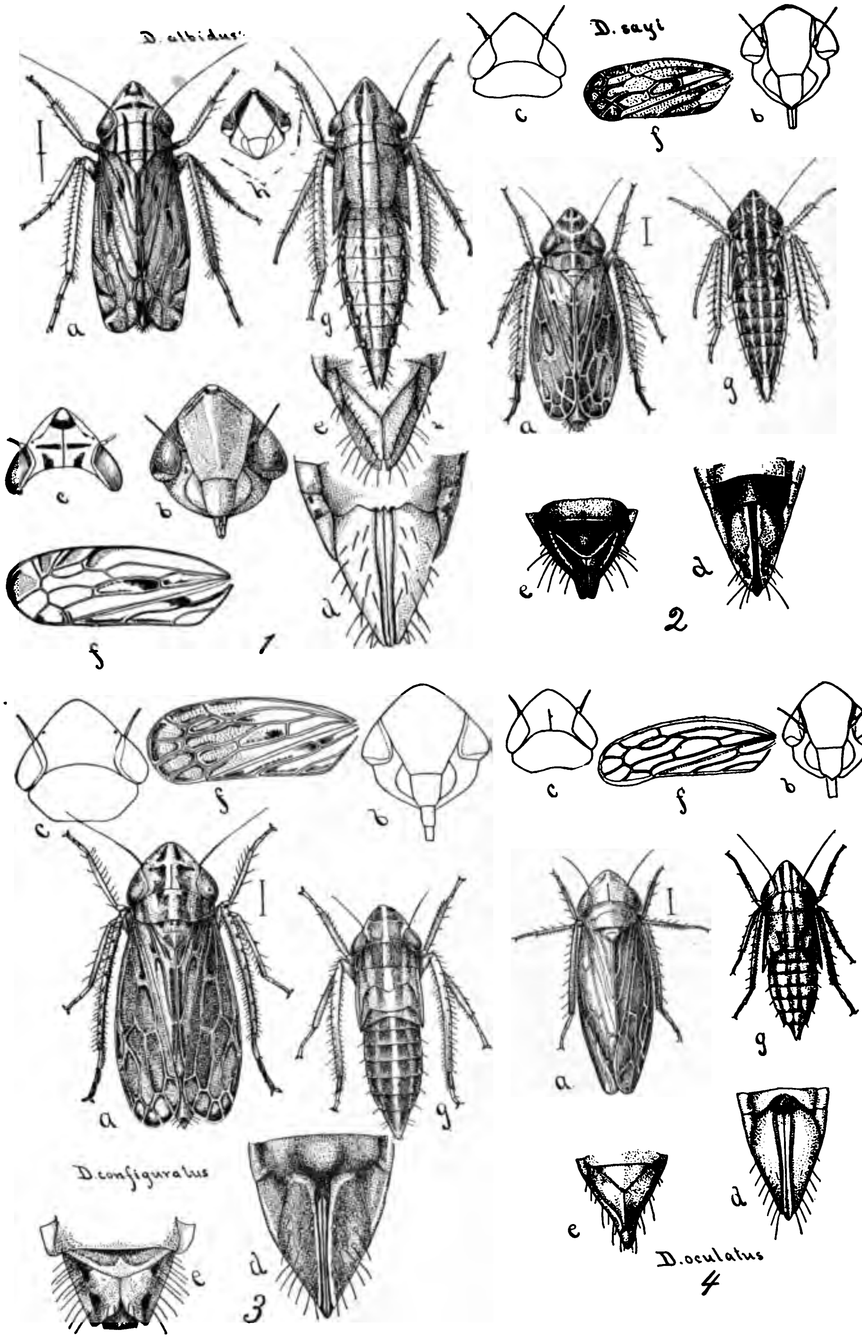
2
D. pectinatus
3
D. abbreviatus
4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D. sayi
D. configuratus
D. oculatus
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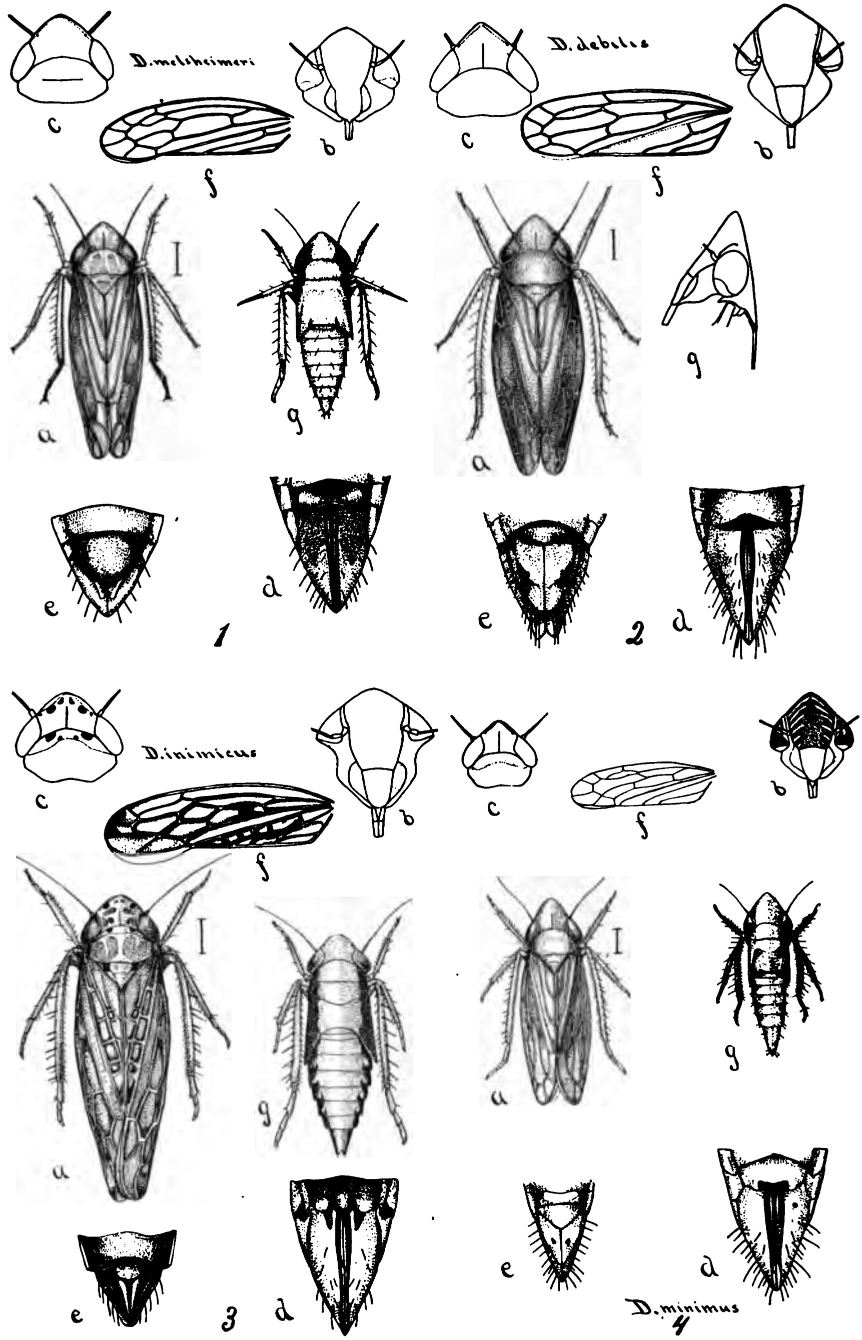
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D. inimicus
D. minimus
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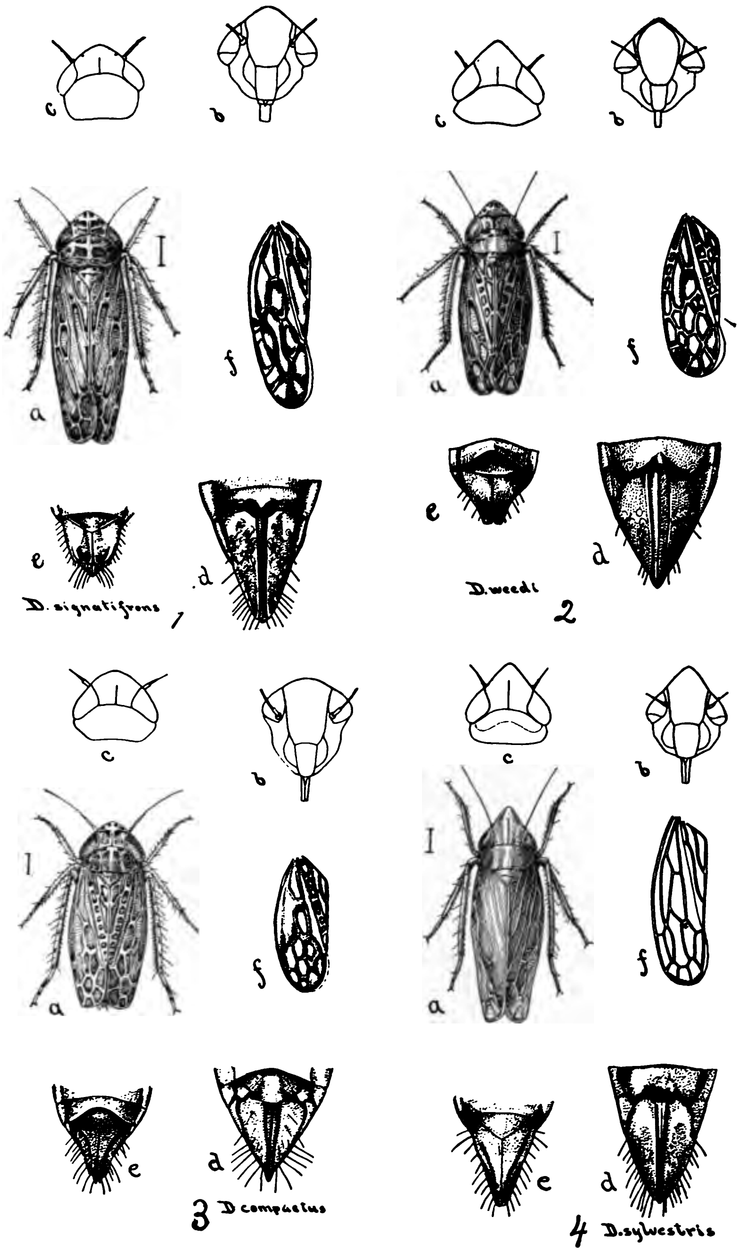
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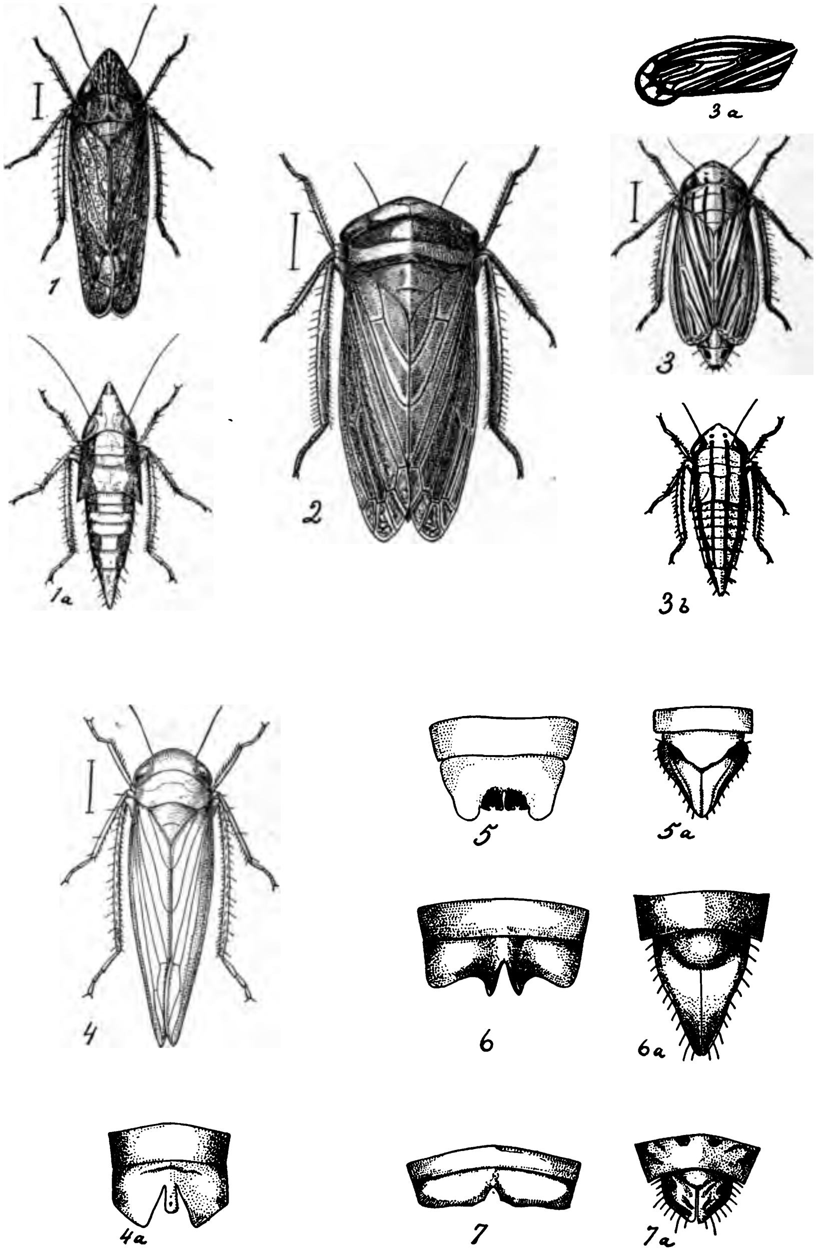
D. weedi 2
3 D compactus
4 D. sylvestris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6a
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7a

In working over the additional material accumulated, and in rearranging the Orthopterous collection of the Iowa Agricultural college during the early part of the year several additional species were found; these, with some material collected in Lyon and Mahaska counties several years ago, together with the collecting of the present season at Ames, have furnished the basis for an addition of some 30 species to the list published by Professor Osborn in the proceedings of this academy for 1891.

Owing to the fact that there has been considerable revision in nomenclature and synonomy since the publication of the former list, thus rendering necessary a number of changes, and further that a majority of the species would be included in the notes, it has been thought best to make the list of species complete, although in a number of cases nothing additional can be given.

The arrangement of families in the list is purely arbitrary, for as yet there seems to be no satisfactory arrangement based upon philogenetic deductions. Within the families the ordinary arrangement has been adopted except where there has been recently suggested changes. In the groups Tettiginæ and Tryxalinæ, Prof. A. P. Morse's recent revision has been followed and in the Tettiginæ he has kindly verified all the determinations. To Professor Scudder I am indebted for the determination of the Ceuthophilus listed. While to Professor Lawrence Bruner I am under obligations for the determination of a number of species and the verification of the greater portion of the remainder of the list.

ORDER ORTHOPTERA.

Fam. FORFICULIDÆ—Earwigs.

Labia minor Linn, A few specimens taken each year.

Fam. BLATTIDÆ—Cockroaches

Ectobia germanica Steph. Common in stores and houses in towns.

Ischnoptera unicolor Scudd. Occasionally taken at Ames. Specimens were found abundantly in the timber around Oskaloosa in June.

Ischnoptera pennsylvanica DeGeer. Abundant in the timber along the larger streams. Adults during early summer, disappearing by the middle of July.

Periplaneta orientalis Linn. This introduced species, which was formerly confined to a few of the larger cities, has spread

over the entire state and is becoming a veritable nuisance, even in the smaller towns of the prairie region.

Periplaneta americana Linn. Specimens of this large southern form have been found at Carbonado, Grand Junction, Little Rock and Ames, but in every case in buildings where bananas were sold, and it is doubtful if they have gained a permanent foothold.

Fam. PHASMIDÆ—Walking Sticks.

Diapheromera femorata Say. Common throughout the timbered portion of the state. Either this or an allied species has been observed very commonly on the prairies of the northwestern portion of the state, during August and September.

Fam. GRYLLIDÆ—Crickets.

Tridactylus apicalis Say. This small species was found rather commonly as nymphs, along the margin of a small stream in August and September, and again the following April. Adults were taken in July.

Gryllotalpa borealis Scudd.

Gryllotalpa columbia Scudd. This and the preceding species are found only in the southern portion of the state. Are they distinct?

Gryllus abbreviatus Serv. The most abundant species in the state occurring everywhere. Sometimes occasions considerable loss in the grain raising sections by cutting the bands of the shocked grain.

Gryllus luctuosus Serv. Rare.

Gryllus pennsylanicus Burm. A few specimens of a broad headed cricket that has been referred here were taken from the timber in July.

Nemobius fasciatus DeGeer. Occurs with abbreviatus in the fields.

Nemobius carolinus Scudd. Common in the woods.

Anaxiphus pulicarius Sauss. A number of these small light colored crickets were taken while sweeping in the woods in July.

Apithes agitator Uhl. One specimen of this southern form has been received from Lee county.

Œcanthus fasciatus Fitch. Abundant everywhere during the latter part of the season.

Œcanthus angustipennis Fitch. Examples of this species appear several weeks earlier than any of *fasciatus*, and may be found rather commonly on the prairie.

Œcanthus niveus Serv. Appears at about the same time as the preceding, but occurs more commonly in the woods.

Œcanthus latipennis Riley. One specimen taken at Ames in September. Probably more common farther south in the state.

Xabea bipunctata DeGeer. Rare.

Fam. LOCUSTIDÆ—Katydids, etc.

Ceuthophilus blatchleyi Scudd. A number found under boards, logs, etc., in July and August.

Ceuthophilus vinculatus Scudd. Common.

Ceuthophilus seclusus Scudd. Rare.

Udeopsylla robusta Hald. Specimens from Little Rock and from the mines of Mahaska county.

Udeopsylla nigra Scudd. Common in holes and cellars.

Pterolepis pachymerus Burm. No specimens have been reported since the former list.

Platyphyllum concavum Say. Rare at Ames.

Amblycorypha oblongifolia Scudd. A few specimens taken each year.

Amblycorypha rotundifolia Scudd. Rather common in the timber, along with the preceding species.

Amblycorypha brachyptera Bruner. Specimens of a much shorter-winged species than either of the above were taken from the prairie of northwestern Iowa some years ago and have been found this season on a few patches of prairie grass at Ames. Professor Bruner has kindly consented to describe it and proposes above name.

Scudderia furculata Brunner.

Scudderia pistillata Bruner. Taken rather commonly from the woods.

Scudderia curvicauda DeGeer. Our most abundant species.

Scudderia furcata Brunner. Common. Smaller than the preceding.

Conocephalus attenuatus Scudd. Common, especially on the prairies.

Conocephalus crepitans Scudd. A single specimen taken at Ames.

Conocephalus ensiger Harr.

Conocephalus nebrascensis Bruner. Fairly common, the brown form is more adundant on the prairies.

Orchelimum nigripes Scudd. Common.

Orchelimum vulgare Harr. Abundant in meadows and low woods where the undergrowth is mainly grasses.

Xiphidium nemorale Scudd. Rather rare.

Xiphidium fasciatum DeGeer. Abundant in meadows everywhere.

Xiphidium attenuatum Scudd. Rare.

Xiphidium brevipenne Scudd. Abundant in low woods and meadows in September and on into October.

Xiphidium nigropleurum Bruner. Rare.

Fam. ACRIDIDÆ—Grasshoppers.

TETTIGINÆ.

Tettix ornatus Say. Abundant in woods and along the margins of the streams.

Tettix arenosus Burm. Common in the timber. More abundant in the early spring than the preceding species.

Tettix granulatus Kirby. This slender form is rather rare.

Paratettix cucullatus Scudd. Adults abundant in the middle of the summer. Larvæ have been taken in the late fall and early spring.

Tettigidea parvipennis Harr. Abundant in low timber land, where the undergrowth is short. The long-winged form, *pennata*, is much more abundant than the other.

TRYXALINÆ.

Pseudopomala brachyptera Scudd. Small larvæ of this species were taken May 12th, and from then until July 3rd, when the last, a full grown female pupa was found. The first adult, a male, was taken June 6th; the first female was taken July 3rd, and the last September 12th. All of these specimens were found on prairie grass principally *Andropogon scoparius*.

Mermiria bivittata Serv. One specimen.

Dicromorpha viridis Scudd. Rather rare. Adult males were taken July 4th and 30th, the females mainly in August.

Eritettix tricarinatus Thos. This species hibernates as nearly full grown larvæ. Adults were first found April 24th and were taken from then until July 4th. Small larvæ were first found the last of August and were abundant throughout the fall until into October. This species was also found on *A. scoparius* and occurred sparingly on the *Bouteloas*.

Orphula speciosa Scudd. Common from July until September as adults on the prairie grasses. Larvæ have been taken from the first of May until July.

Chloealtis conspersa Harr. Adults were taken this season from June 17th until into September, from a moderately shaded pasture.

Stenebothrus curtipennis Harr. Common; occurs at about the same time and in similar situations with *O. æqualis*.

Mecostithus platypterus Scudd. A single specimen collected at Little Rock, Lyon county. Swept from a meadow.

Mecostithus lineatus Scudd. Scott county. (MacNeil.)

Boopedon nubilum Say. Rare. Two specimens taken in July, 1894.

Eremnus scudderi Bruner. Found in abundance on the top of a sandy knoll August 4th, and from then on until the middle of September. The grass on the knoll consisted almost entirely of *B. hirsuta*.

ŒDIPODINÆ.

Chortophaga viridifasciata DeGeer. Adults appear by the 20th of April continuing abundant until the middle of the summer; larvæ appear in August, becoming nearly full grown before winter.

Encoptolophus sordidus Burm. Common on sandy and exposed places throughout the fall.

Arphia xanthoptera Burm. Common in open fields from the middle of August until October.

Arphia carinata Scudd. Common with the preceding.

Arphia conspersa Scudd. Two specimens mentioned in the former list.

Arphia sulphurea Fab. Rather rare. One male was taken May 15th, and another May 23rd.

Hippiscus haldemanni Scudd. Common. Little Rock and Ames.

Hippiscus tuberculatus Pal Beauv. Common in early summer.

Hippiscus variegatus Scudd. Specimens were taken abundantly from the sand knoll from August 20th to September 24th, but were not found anywhere else. Very small larvæ were found with the adults August 20th, so they must have appeared much earlier. The larvæ were about one-third grown by the last of September. The smaller ones had deep red hind tibiæ

Hippiscus (Xanthippus) zanotecus Sauss. Denison, July 15th; J. A. Allen (Scudder; Psyche 6–392).

Dissosteira carolina Linn. Common.

Spharagemon collare Scudd. Rare.

Spharagemon bolli Scudd. Fairly common along margins of woods and in open places.

Trachyrhachis cincta Thos. Common on sandy places and southern slopes from the middle of July until late in the fall.

Trimerotropis citrina Scudd. Rather rare. Iowa City and Ames.

ACRIDIANÆ.

Brachistola magna Girard. Only found in the western part of the state.

Schistocerca americana Drury. Lee county. Probably occurs throughout the southern part of the state.

Schistocerca alutacea Harr. Isolated individuals have been found from the middle of August on through September.

Schistocerca emarginata Uhl. Common along railway embankments and in hazel brush thickets in August and September. Either a very distinct variety of the above or else another larger species, with bright red or yellow hind tibiæ, and sharply defined black lines under the eyes, was found very commonly in a low marshy place overgrown with willows the last of September.

Hesperotettix pratensis Scudd. Rare. A few examples taken from the sides of the gravel knoll from August 4th to September 3d.

Melanoplus scudderi Uhl. Common in dry open woods in August and September.

Melanoplus occidentalis Bruner. This and the two following species included for the western part of the state on the authority of Professor Bruner.

Melanopus gracilis Bruner.

Melanoplus albus Dodge.

Melanoplus differentialis Thos. Common about roadways and margins of fields. Adults from August through October. Sometimes quite destructive to corn.

Melanoplus bivitattus Say. Common as adults from July till October.

Melanoplus packardi Scudd. One specimen August 1st.

Melanoplus dawsoni Scudd. High open woods. Adults were taken from June 6th until July 7th, this season.

Melanoplus angustipennis Dodge. Iowa City and Ames. Taken from an open woods and along the margin of an adjoining corn field, from the middle of August until the last of September.

Melanoplus minor Scudd. Rare. A few specimens taken August 11th.

Melanoplus punctulatus Scudd. Rare. Des Moines and Ames in September.

Melanoplus femur-rubrum DéGeer. Too common.

Melanoplus luridus Dodge. This species was taken abundantly from the knolls during July and August.

Melanoplus abditum Dodge. This and the following species included on the authority of Professor Bruner.

Melanoplus junius Dodge.

Melanoplus atlanis Riley. Three specimens of this species were taken September 11th from a high gravel point.

Melanoplus spretus Thos. An occasional specimen of this species taken here.

Phoetaloites nebrascensis Thos. Short-winged examples of this unique species fairly common on prairie grass during August and September.

ADDITIONS AND CORRECTIONS.

Page 8, under associate members, add Grant E. Finch, West Union.
" 74, line 7, for *not common* read *rather common.*
" 75, line 3, for *Physia* read *Physcia.*
" 75, line 14, for *list* read *lists.*
" 80, line 14, for *pussillus* read *pusillus.*
" 84, bottom line, for *Lepidum* read *Lepidium.*
" 86, line 22, for *Futaceæ* read *Rutaceæ.*
" 88, line 11, for *Amphicarphæ* read *Amphicarphæa.*
" 88, line 20, for *Spiræ* read *Spiræa.*
" 89, line 23, for *Umaerlliferæ* read *Lythraceæ.*
" 90, line 7, for *Cryptonœnia* read *Cryptotænia.*
" 91, line 16, for *Veronia* read *Vernonia.*
" 92, line 2 from bottom, for *augustifolia* read *angustifolia.*
" 113, line 10, for *lepieota* read *lepidota.*
" 119, line 5, for *aspert* read *asper.*
" 120, line 20, for *sells* read *cells.*
" 121, line 7, for *nivilis* read *mollis.*
" 172, line 17, for *history* read *histories.*
" 179, line 3, for *synonym* read *synonomy.*

INDEX.